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THIRTY-SIXTH ANNUAL REPORT

of

✓
Forage Research

in the

Northeastern United States

1972

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1972
Thirty-Sixth Annual Report
of
Forage Research
in the
Northeastern United States

A Joint Contribution of the
U.S. Regional Pasture Research Laboratory
and the
Agricultural Experiment Stations
of the
Twelve Northeastern States

Participating Agencies
Beltsville Agricultural Research Center,
Chesapeake-Potomac Area, and
North Atlantic Area
of the Northeastern Region
Agricultural Research Service, U.S. Department of Agriculture
and the

Agricultural Experiment Stations of

Connecticut (Storrs)
Delaware
Maine
Maryland
Massachusetts
New Hampshire
New Jersey

New York (Cornell)
New York (Geneva)
Pennsylvania
Rhode Island
Vermont
West Virginia

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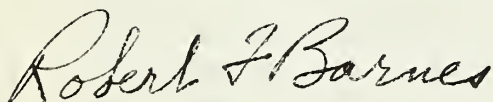
PREFACE

This Annual Report is intended primarily for use by forage research and extension workers in the Northeastern United States. It contains brief reports of research projects carried on at most of the State Agricultural Experiment Stations in the region. It also includes reports from several Regional Research Technical Committees and research personnel of the Northeastern Region, Agricultural Research Service, U.S. Department of Agriculture. Our appreciation is extended to all contributors and to the contact person at each station who coordinated the collection of reports.

Over 100 reports were received which involved more than 120 scientists. The reports are divided topically into various sections. For convenience an author index has been prepared. A roster is included of research and extension workers in the Northeastern United States who devote at least a portion of their time to forage and grassland research or extension activities. Publications appearing since the last report and names of individuals receiving their advanced degrees in 1972 are listed.

The role of forage and grassland research in the Northeast must be considered in a new light in today's society. Traditional views and approaches must be reexamined and tested to determine if they can meet the greatly increasing demands for food and fiber in the future. Where these traditional views are found lacking, new methods, new approaches, and new ideas must be formulated through research. It is hoped that this compilation of information on forage and grassland research in the Northeastern United States will be of value in the assessment of research goals and priorities for the future.

We would appreciate your thoughts and suggestions on how we might make this report more accurate and relevant in the future.

A handwritten signature in cursive script that reads "Robert F. Barnes". The signature is written in dark ink and is positioned above the printed name and title.

Robert F. Barnes
Laboratory Director

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Roster of Research and Extension Workers in the Northeastern
United States with Some Emphasis on Forage Crops and Grasslands

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Connecticut</u>		
Storrs 06268		
Allinson, D. W.	Forage Management	Plant Science
Cowan, W. A.	Animal Nutrition	Animal Industries
Dest, W. M.	Weed Investigations	Plant Science
Fellows, I. F.	Agricultural Economics	Agricultural Economics
Griffin, G. F.	Soil Fertility	Plant Science
Peters, R. A.	Weed Investigations	Plant Science
Prince, R. P.	Agricultural Engineering	Agricultural Engineering
Washko, W. W.	Forage Management	Plant Science
Wengel, R. W.	Soil Physics	Plant Science
<u>University of Delaware</u>		
Newark 19711		
Crittenden, H. W.	Legume Diseases	Plant Science
Fowler, R. E.	Beef Cattle Nutrition	Animal Science and Agricultural Biochemistry
Haenlein, G. F. W.	Nutritive Evaluation	do.
Jones, E. R.	Forage Management	Dept. of Agriculture Delaware State College Dover, Del. 19901
Mitchell, W. H.	Forage Management	Plant Science
Reitnour, C. M.	Horse Physiology	Animal Science and Agricultural Biochemistry
Svec, L. V.	Physiology	Plant Science
<u>University of Maine</u>		
Orono 04473		
Apgar, W. P.	Forage Utilization	Animal and Veterinary Sci.
Brown, C. S.	Forage Management	Plant and Soil Sciences
Dickey, H. C.	Forage Preservation	Animal and Veterinary Sci.
Holyoke, V. H.	Silage Corn Management	Plant and Soil Sciences
Rowe, R. J.	Engineering Harvesting	Agricultural Engineering
Simpson, G. W.	Forage Insects	Entomology

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
Rutgers University, The State University of New Jersey New Brunswick 08903		
Duell, R. W.	Highway Vegetation	Soils and Crops
Evans, J. L.	Nutritional Value	Animal Science
Halisky, P. M.	Plant Pathology	Plant Biology
Ilnicki, R. D.	Weed Control	Soils and Crops
Mears, D. R.	Agricultural Engineering	Engineering
Race, S. R., Jr.	Forage Insects	Entomology and Economic Zoology
Ramage, C. H.	Production Utilization	Animal Science
Singley, M. E.	Engineering, Utilization	Engineering
Sprague, M. A.	Management, Preservation	Soils and Crops
Vander Noot, G. W.	Forage Utilization	Animal Science
Cornell University (New York) Ithaca 14850		
Campbell, J. K.	Agricultural Engineering	Agricultural Engineering
Duke, W. B.	Weed Control	Agronomy
Fick, G. W.	Forage Physiology and Management	Agronomy
Grunes, D. L.	Soils & Plant Nutr.	U.S. Plant, Soil and Nutrition Laboratory*
Gyrisco, G. G.	Entomology	Entomology
Helgesen, R. G.	Entomology	Entomology
Linscott, D. L.	Weed Control	Agronomy
Lowe, C. C.	Genetics and Breeding	Plant Breeding and Biometry
Lucey, R. F.	Forage Management	Agronomy
Millar, R. L.	Plant Pathology	Plant Pathology
Millier, W. F.	Agricultural Engineering	Agricultural Engineering
Murphy, R. P.	Genetics and Breeding	Plant Breeding and Biometry
Pardee, W. D.	Forage Management	do.
Reid, J. T.	Animal Nutrition	Animal Science
Schaaf, H. M.	Genetics and Breeding	Plant Breeding and Biometry*
Seaney, R. R.	Forage Management	Agronomy
Van Soest, P. J.	Animal Nutrition	Animal Science
Wright, M. J.	Forage Management	Agronomy

* USDA-ARS Cooperative appointment.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>New York State Agricultural Experiment Station</u> Geneva 14456		
Dolan, D. D.	Plant Introduction	Seed Investigations and ARS, USDA
Fleger, F. L.	Plant Pathology	do.
Nittler, L. W.	Seed Research	Seed Investigations
<u>The Pennsylvania State University</u> University Park 16802		
Ace, D. L.	Dairy Extension	Dairy Science
Adams, R. S.	Dairy Extension	Dairy Science
Barr, W. L.	Farm Management	Agricultural Economics and Rural Sociology
Bartlett, H. H.	Agricultural Engineering	Agricultural Engineering
Baumgardt, B. R.	Animal Nutrition	Animal Science
Baylor, J. E.	Pasture and Forage Crops (Extension)	Agronomy Extension
Bloom, J. R.	Nematode Control	Plant Pathology
Burdette, L. A.	Animal Nutrition Ext.	Animal Science
Cash, E. H.	Animal Nutrition	Animal Science
Cleveland, R. W.	Genetics and Breeding	Agronomy
Cowan, R. L.	Animal Nutrition	Animal Science
Downs, W. G.	Forage Management	Agronomy (P.O. Rector)
Dum, S. A.	Farm Management Ext.	Economics
Guss, S. B.	Veterinary Sci. Ext.	Veterinary Science
Hershberger, T. V.	Animal Nutrition	Animal Science
Hower, A. A., Jr.	Forage Insects	Entomology
Johnson, M. W.	Corn Breeding	Agronomy
Kardos, L. T.	Soil Physics	Agronomy
Kesler, E. M.	Dairy Science	Dairy Science
Kjelgaard, W. L.	Agricultural Engineering	Agricultural Engineering
Kradel, D. C.	Veterinary Medicine	Veterinary Science
Long, T. A.	Animal Nutrition	Animal Science
Lukezic, F. L.	Forage Pathology	Plant Pathology
Marriott, L. F.	Soil Fertility	Agronomy
McKee, G. W.	Ecology, Physiology	Agronomy
Merritt, T. L.	Animal Science	Animal Science
Partenheimer, E. J.	Agricultural Economics	Agricultural Economics and Rural Sociology
Risius, M. L.	Genetics and Breeding	Agronomy
Shenk, J. S.	Forage Grass Breeding	Agronomy
Starling, J. L.	Genetics and Breeding	Agronomy
Thomas, W. I.	Representative NE	Agricultural Experiment Station
Wangness, P. J.	Animal Nutrition	Animal Science
Washko, J. B.	Forage Management	Agronomy
Wilson, L. L.	Animal Science	Animal Science
Yendol, W. G.	Non-Pesticide Insect Control	Entomology

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Rhode Island</u>		
Kingston 02881		
Henderson, B. W., Jr.	Animal Nutrition	Animal Science
Wakefield, R. C.	Management	Plant and Soil
<u>University of Vermont</u>		
Burlington 05401		
Bartlett, R. J.	Soil Science	Plant and Soil Science
Benoit, G. R.	Soil Physics	do.
Bornstein, J.	Agricultural Engineering	Agricultural Engineering
MacCollom, G. B.	Entomology	Entomology
McIntosh, J. L.	Soil Science	Plant and Soil Science
Parker, B. L.	Entomology	Entomology
Schneider, E. C.	Agricultural Engineering	Agricultural Engineering
Smith, A. M.	Animal Nutrition	Animal Sciences
Varney, K. E.	Forage Management	Plant and Soil Science
Welch, J. G.	Nutritional Value	Animal Sciences
Wilson, D. M.	Pathology	Botany
Wood, G. M.	Forage and Turf Mgmt.	Plant and Soil Science
<u>West Virginia University</u>		
Morgantown 26506		
Anderson, G. C.	Animal Nutrition	Animal and Veterinary Sci.
Baker, B. S.	Forage Management	Allegheny Highlands Project, Elkins, W.Va.
Balasko, J. A.	Forage Physiology	Plant Sciences
Bennett, O. L.	Forage Management	Plant Sciences and ARS, USDA
Butler, Linda	Entomology	Plant Sciences
Diener, R. G.	Agricultural Engineering	Resource Management
Elliott, E. S.	Root Diseases	Plant Sciences
Horvath, D. J.	Animal Nutrition	Animal and Veterinary Sciences
Kneefer, R. F.	Soil Fertility	Plant Sciences
Maxwell, R. H.	Agricultural Education	Allegheny Highlands Project, Elkins, W.Va.
Pohlman, G. G.	Soil Fertility	Plant Sciences (Emeritus)
Reid, R. L.	Animal Nutrition	Animal and Veterinary Sciences
Thomas, R. O.	Dairy Nutrition	do.
Toben, G. E.	Agricultural Economics	Resource Management
Ulrich, Valentin	Plant Breeding	Plant Sciences
Veatch, Collins	Weed Control	Plant Sciences (Emeritus)

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<u>Name</u>	<u>Field of Research</u>	<u>Laboratory</u>
Beltsville Agricultural Research Center Northeastern Region, Agricultural Research Service U.S. Department of Agriculture Beltsville, MD 20705		
Bond, James	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Carlson, G. E.	Plant Physiology	Plant Physiology Institute Light and Plant Growth Lab
Chatterton, N. J.	Biochemistry	do.
Derbyshire, J. C.	Dairy Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Devine, T. E.	Alfalfa Breeding	Plant Genetics & Germplasm Inst. Applied Plant Genetics Lab
Dinius, D. A.	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Goering, H. K.	Dairy Nutrition	do.
Hanson, C. H.	Alfalfa Breeding and Genetics	Plant Genetics & Germplasm Inst. Applied Plant Genetics Lab
Hart, R. H.	Forage Management	Plant Physiology Institute Light and Plant Growth Lab
Juska, F. V.	Grass and Turf Management	Plant Genetics & Germplasm Inst. Turfgrass Laboratory
Klingman, D. L.	Weed Control	do.
Lindahl, I. L.	Sheep Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Lynch, G. P.	Dairy Nutrition	do.
Moe, P. W.	Energy Metabolism	do.
Murray, J. J.	Turfgrass	Plant Genetics & Germplasm Inst. Turfgrass Laboratory
Neal, J. W., Jr.	Forage Insects	Plant Genetics & Germplasm Inst. Applied Plant Genetics Laboratory
Oltjen, R. R.	Beef Nutrition	Nutrition Institute Ruminant Nutrition Laboratory

<u>Name</u>	<u>Field of Research</u>	<u>Laboratory</u>
<u>Beltsville Agricultural Research Center (cont'd.)</u>		
Ostazeski, S. A.	Plant Pathology	Plant Genetics & Germplasm Inst. Turfgrass Laboratory
Powell, J. B.	Genetics	do.
Ratcliffe, R. H.	Forage Insects	Plant Genetics & Germplasm Inst. Applied Plant Genetics Laboratory
Reynolds, P. J.	Sheep Nutrition	Nutrition Institute Ruminant Nutrition Laboratory
Rumsey, T. S.	Beef Nutrition	do.
Schroder, R. F. W.	Forage Insects	Plant Genetics & Germplasm Inst. Applied Plant Genetics Laboratory
Tyrrell, H. F.	Energy Metabolism	Nutrition Institute Ruminant Nutrition Laboratory
Waldo, D. R.	Dairy Nutrition	do.

U.S. Regional Pasture Research Laboratory
 North Atlantic Area, Northeastern Region
 Agricultural Research Service
 U.S. Department of Agriculture
University Park, PA 16802

Barnes, R. F.	Forage Evaluation	U.S. Regional Pasture Res. Lab.
Berg, C. C.	Genetics (Grasses)	do.
Byers, R. A.	Forage Insects	do.
Fissel, G. W.	Chemist	do.
Gross, C. F.	Soil Fertility	do.
Gustine, D. L.	Biochemistry	do.
Hill, R. R., Jr.	Genetics (Alfalfa)	do.
Jung, G. A.	Forage Management	do.
Kendall, W. A.	Plant Physiology	do.
Leath, K. T.	Pathology (Legumes)	do.
Sherwood, R. T.	Pathology (Grasses)	do.
Wilton, A. C.	Cytogenetics (Grasses)	do.
Zeiders, K. E.	Plant Pathology	do.

SECTION I

BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH

Title: Report of Northeast Regional Plant Introduction Station, Geneva, N.Y.; and Regional Project NE-9--The Introduction, Testing, Multiplication and Preservation of Potentially Valuable Plants for Crop Improvement and Industrial Use

Leaders: D. D. Dolan and F. L. Pfleger, New York (Geneva)

An article entitled "Field Resistance to Pseudopeziza medicaginis in Alfalfa Introductions" was recently published in Plant Disease Reporter 57:468-471, May 1973. This article gives the results of field testing of 58 alfalfa introductions and 5 standard cultivars for tolerance or resistance to leafspot under field conditions. Four introductions were rated highly resistant. These four are P.I. 325384, 325383, 325382, and 211608. Also two Geneva numbers were rated highly for tolerance. These are G-15178 and G-15179. A study of fungal penetration and mycelial development in the leaves of highly resistant introductions indicated that both penetration and development were severely retarded and restricted. In susceptible accessions penetration, colonization, and mycelial proliferation were abundant.

At the end of the 1972 growing season, the Regional Plant Introduction Station prepared as an appendix to the Annual Report a section entitled "Promising Introductions of 1972." Pages 3-5 of this report listed the most promising introductions of each of the following species: Medicago sativa, Medicago falcata, Trifolium pratense, Trifolium repens, Trifolium hybridum, and Lotus corniculatus. Copies of this release are still available from the Coordinator.

The same publication contained a section on pages 6-8 of promising forage grass introductions as seen in the field planting during 1972. This section lists the most promising forage grass introductions with regard to both agronomic characters and disease tolerance or resistance and lists introductions of each of the following species: Arrhenatherum elatius, Bromus inermis, Dactylis glomerata, Festuca arundinacea, Lolium perenne, Phalaris arundinacea, and Phleum pratense. Again, copies of this release are available from the Coordinator, NE-9.

Cooperators in Regional Project NE-9 located at each of the 14 State Agricultural Experiment Stations of the Northeastern Region continued to test forage legume introductions and forage grass introductions during the 1972 growing season. An abstract of their reports was published on pages 19 and 20 of the release entitled "Promising Introductions of 1972."

Some of the forage legume introductions that appeared promising throughout the Northeastern Region are as follows:

Alfalfa: P.I. 259530 and 268065

Red clover: P.I. 233828, 239697, 251854, 251857, 253320 and 255395

White clover: P.I. 282381, 282380, 282374, 282379, 282377, 239981, 239982, 241460, 243571, 250790, 120107, 195531, 195533, 208730 and 239976

Birdsfoot trefoil: P.I. 251146

Some of the forage grass introductions that appeared promising in tests throughout the Northeastern Region are as follows:

Orchardgrass: P.I. 111536S, 200319, 229446, 289001, 237718, 315420 and 320557

Reed canarygrass: P.I. 235546

The Regional Plant Introduction Station during the year, prepared an article on the construction and use of a force hot-air drying-room that is used for drying forage seed crops harvested at the Plant Introduction Station, Geneva. This article has been accepted for publication and will appear in the Agronomy Journal in the near future.

Title: Regional Project NE-74--Breeding of Improved Varieties of Forage Species Adapted to the Northeast

Leader: C. C. Berg, Pasture Research Laboratory, University Park, Pa., Chairman, Regional Technical Committee

Experiment stations and other agencies with contributing projects:

The Connecticut (Storrs), Maryland, New Hampshire, New York (Cornell), and Pennsylvania Agricultural Experiment Stations; and the U.S. Regional Pasture Research Laboratory, ARS-USDA, University Park, Pa.

Experiment stations and other agencies represented on the technical committee without a contributing project: The Delaware, Maine, New Jersey, Rhode Island, Vermont and West Virginia Agricultural Experiment Stations; Cooperative State Research Service, USDA; Applied Plant Genetics Laboratory and Turfgrass Laboratory, ARS-USDA, Beltsville, Md.; and the American Seed Trade Association

Strain synthesis procedures, seed production and strain evaluation were continued in 1972. Work is in progress on seven species at five Northeastern State Experiment Stations; and ARS, USDA at the U.S. Regional Pasture Research Laboratory, and at Beltsville, Md.

I. Studies on strain synthesis:

Alfalfa. Syn 2 seeds of 100 experimental synthetics with 1 to 16 parental clones were produced. Plants for the production of Syn 3 seed have been established in the greenhouse (Pasture Lab). Inbred lines for use as parents in synthetics or hybrids are being developed for the varieties Saranac and Iroquois. Selected S₃ plants will be used to produce S₄ lines for synthesis combinations to measure effects of parent line inbreeding (NY).

Orchardgrass. Synthetic products (conventional synthetics, restricted polycrosses, single crosses, and double cross synthetics) were not superior to the source varieties (Pennlate and Pennmead) for forage yield; however, significant differences in yield occurred among single crosses, indicating that specific combining ability is important (PA).

Bromegrass. The superiority of Syn 1 over Syn 2 in forage production continued to decline each year (approximately 0.7 tons/ha in 1970 to 0.2 tons/ha in 1971 to 0.04 tons/ha in 1972).

Timothy. Single clone derived lines of timothy are being used to study synthesis behavior. Seed is being produced from five two-line combinations to study synthesis procedures.

II. Genetic studies:

Alfalfa. Single clone derived families (S₀ to S₃ and intercrosses of inbred generations) respond differently to inbreeding depression. Year by family interactions were significant for plant height on each of three cutting dates. Average yield of single crosses between S₀ clones was greater than the yield of the clones (Pasture Lab). Anthracnose resistant strains have been developed by recurrent phenotypic selection (ARS). A slight improvement in resistance to Sclerotinia trifoliorum was observed after one cycle of selection. Selection is continuing (MD).

Bromegrass. Chromosome aberrations were more frequent in 4N than in 8N cells. A polyhaploid clone had 2n = 28 plus one or two B-chromosomes in root tip cells. Stomate frequency decreased from the flag to lower leaves, and were more frequent on upper than on lower leaf surfaces. Varieties differed in frequency of stomata on both the upper and lower surfaces to the flag leaf. Selfed seed was produced to obtain progeny to study the genetics of albino and rolled leaf mutants (NH).

III. Seed production:

Seed increases (alfalfa) were obtained in a Saranac-type variety with southern anthracnose resistance, a Saranac-type variety with higher yield potential, and a multifoliolate synthetic (NY). Medium to late maturity timothy synthetics, wide genetic base trefoil synthetics (NY), and bromegrass synthetics (NH) were increased for regional forage evaluation. Artificial air movement did not significantly increase seed production of Lolium-Festuca hybrids in muslin cages (Pasture Lab).

IV. Evaluation of new synthetics:

Promising public and privately developed alfalfa varieties were tested in uniform trials in NY, PA, CT, and MD to provide a comprehensive picture of performance in the Northeast. Anthracnose resistant strains produced high yields and maintained good stands while susceptible varieties were severely injured by anthracnose (MD). Forage yield from trefoil synthetics was equal to but not superior to existing varieties.

Title: Regional Project NE-75--Breeding for Improved Forage Quality

Leader: J. S. Shenk, Pennsylvania, Chairman, Regional Research Committee

Experiment stations and other agencies with contributing projects:

The Maryland, Minnesota, New York (Cornell), Pennsylvania, South Dakota and Wisconsin Agricultural Experiment Stations; and the U.S. Regional Pasture Research Laboratory, ARS-USDA, University Park, Pa.

Experiment stations and other agencies represented on the technical committee without a contributing project: The Connecticut (Storrs), New Hampshire, New Jersey, and West Virginia Agricultural Experiment Stations; Cooperative State Research Service, USDA; and Applied Plant Genetics Laboratory, Light and Plant Growth Laboratory, and Turfgrass Laboratory, ARS-USDA, Beltsville, Md.

I. Characterize the variability in plant constituents.

Individual plants of orchardgrass (PA), alfalfa (NY), smooth brome grass (SD), outcrossed progenies of timothy plants (NY), and open pollinated progeny of big bluestem (SD) were evaluated for in vitro dry matter disappearance (IVDMD). Significant differences were found among plants and cuttings in the first four species but significant harvest x plant interactions were also present. Significant genetic variability for quality traits was found in alfalfa (Pasture Lab). Highly additive genetic effects were indicated in the IVDMD analysis of intermediate wheatgrass although some specific combining effects and reciprocal effects were also present (SD). Broad-sense heritability estimates for the acid-pepsin digestion technique in brome grass were quite high (WI). Broad-sense realized heritability for alkaloid concentration in reed canarygrass was high and higher than or equal to narrow sense heritability. Total genetic variance was largely additive, particularly in the low alkaloid range (MN).

II. The application of approximate techniques.

Initial screening of plant populations may best be made on the basis of the percentage of DM and/or visual observations because of sampling limitations (NY). Heavy nitrogen or phosphorus applications appeared to affect genetic expression of quality traits in bromegrass. Comparison of the two-stage Tilley and Terry technique with the acid pepsin digestion procedure and with protein shows very low relationships in fertility experiments (SD). Correlations among quality measurements in alfalfa plants selected for the percentage of protein revealed a positive relationship between protein and NDF, but not with ADF or IVDMD (MD). Palatability of reed canarygrass plants was a function of plant rather than animal differences. Addition of reagent alkaloids did not significantly affect IVDMD of reed canarygrass. Results suggested that rapid initial gain in reducing total alkaloid concentration could be expected but that the gain would be slower at the low end of the alkaloid range (MN). Crownvetch forage contained an unidentified substance(s) that was not only toxic to meadow voles but chicks as well. Progress has been made in the isolation and identification of this substance(s) (PA, Pasture Lab).

III. The development of source populations.

A second-cycle of selection has been made for higher protein concentration in alfalfa (MD). Polycross nurseries of highly digestible plants with desirable seed set and agronomic characteristics have been established for intermediate wheatgrass (SD), orchardgrass (PA), and crownvetch (PA).

IV. Plant morphological and physiological characteristics.

The association among morphological characteristics and acid-pepsin digestibility was not strong in bromegrass (WI). Correlations of IVDMD and protein with morphological characteristics in orchardgrass were generally significant in first harvest, but no simple morphological characteristic seemed to be associated with forage quality in the aftermath harvest (PA).

V. The production of synthetic varieties.

Synthetics are being developed for agronomic evaluation and animal feeding trials by a number of the cooperators.

Title: Floral Induction and Development in Festuca rubra L.:
Differential Clonal Response to Environmental Conditions

Leaders: J. J. Murray, USDA, ARS, Beltsville, Md.; A. C. Wilton,
Pasture Research Laboratory, University Park, Pa., and
J. B. Powell, USDA, ARS, Beltsville, Md.

At Beltsville, Md. we found that in red fescue, Festuca rubra L., when plants were brought indoors for intercrossing, early flowers and adequate amounts of seed were produced after (a) a sufficiently long cool induction period in the field, (b) 4 weeks growth at cool temperatures under normal and supplemental light, and (c) warmer temperatures and supplemental light just prior to and during anthesis. Observations made after the (b) growth period were that the frequency of floral primordia increased progressively from zero on plants brought in November 12 to 171 on those brought in January 2. However, clones varied considerably in inductive requirements.

After induction, plants grown under (b) conditions in normal daylight at 10 C were an average of 13 days earlier to head than plants grown under continuous light at the same temperature. Vigorous heading only occurred during the final developmental period (c) when there was normal daylight plus supplemental light at 21-24 C or 21-35 C. Dormancy of harvested seed was broken by 4 weeks storage at 10 C.

Title: Chromosome Variability in Some Poa pratensis L. Cultivars

Leaders: A. C. Wilton, Pasture Research Laboratory, University Park, Pa. and J. J. Murray, USDA, ARS, Beltsville, Md.

The frequency of chromosomal "off types" in twin plants in some Kentucky bluegrass, Poa pratensis L., cultivars currently grown in the U.S. was studied. The chromosome numbers of 12 of these cultivars were determined and the reliability of chromosome counts as cultivar diagnostic guides was studied. Twin plants from six cultivars were separated after caryopses had decayed, grown separately in pots, and root tips excised from them. Average chromosome counts, as well as the range of chromosome counts, were reported. The Fylking cultivar had 1 out of 5 sets of chromosomally divergent twins. Park had 5 out of 8, Belturf 1 out of 5, Cougar 1 out of 7 and Newport 1 out of 7. Nugget had no divergent twins. Seven divergent twins were diplo-triplo chromosome combinations and 2 were diplo-quadruple combinations. Twins were believed to be a good source of variable plant material.

It was also concluded that despite variable counts within plants there were characteristic ploidy levels for most cultivars, particularly

where a cultivar descended from a single clone. Chromosome number, however, was not considered to be reliably uniform throughout any cultivar.

Title: Karyology and Relationships with Phleum pratense,
P. commutatum and P. bertolonii (P. nodosum)

Leaders: A. C. Wilton, Pasture Research Laboratory, University
Park, Pa. and L. J. Klebesadel, USDA, ARS, Palmer, Alaska

Two polyploid and one diploid timothy species are found in North America: Phleum pratense L. ($2n = 42$), P. alpinum var. commutatum Gaud. ($2n = 28$) and P. bertolonii (previously P. nodosum) L. ($2n = 14$). Both karyotypes and photomicrographs of P. pratense and P. commutatum, and a photomicrograph of P. bertolonii are available.

Chromosome arm length measurements, arm length ratios, and other detailed observations showed that P. pratense has three pairs of short acrocentric chromosomes, three pairs of long sub-metacentric chromosomes and three pairs of equi-sized satellited chromosomes. P. commutatum has two pairs of small acrocentric chromosomes, one pair of long metacentrics, a slightly shorter pair of sub-metacentrics and a pair of satellited chromosomes. This and other data obtained from photomicrographs of cells of commutatum plants from Alaska and Wyoming suggest that P. commutatum may have one genome in common with P. pratense genomes. All indications were that P. pratense was an autohexaploid and commutatum an allotetraploid. According to our limited observations the P. bertolonii genome was karyotypically similar to the P. pratense genome.

Title: Inbreeding in Alfalfa

Leader: R. R. Hill, Jr., Pasture Research Laboratory, University Park,
Pa.

This study has been described in previous Reports of Forage Research in the Northeast (see 1971 Annual Report, p. 13). Single crosses between S_0 , S_2 , and S_4 parental lines were transplanted to the field in the spring of 1971. Yield and other agronomic data were collected during the summer of 1972. Single crosses between S_0 clones yielded more than the vegetative cuttings of the parents in both populations of single crosses. A decrease in yield was observed for single crosses between S_2 lines. One population exhibited an increase in yield, and the other a decrease in yield, for single crosses between S_4 lines.

Data were obtained on single clone derived progenies from three families in each of two germplasm pools (see 1970 Annual Report, p. 13). Preliminary analysis of the data indicated that genotype of the parent clones had significant effects on the response to inbreeding in the different progenies. A significant year by family interaction was observed for plant height at each of the harvest times.

Title: Breeding for Improved Forage Quality

Leaders: J. A. Schillinger and L. S. Bull, Maryland

This project, aimed at improving the nutritive quality of several important forage species in the Northeastern United States, was initiated in 1971. The forage species being studied in Maryland include alfalfa and crownvetch.

Alfalfa contains protein of excellent quality. However, the quantity of protein within alfalfa plants varies greatly, and the amount present in alfalfa forage is affected by maturity and environmental factors.

These studies were initiated to increase the level of protein in new alfalfa strains and to improve the consistency of its presence in the forage materials. Simazine has been found to enhance protein synthesis in several species of plants, and it is recommended as a dormant weed control chemical in alfalfa. We have exposed spaced planted alfalfa populations to Simazine at 1 lb/acre and then selected first for vigor and tolerance to Simazine and secondly for protein content (%) and total protein/plant (% protein x dry weight of plant).

After two cycles of selection, average protein content has been increased from 20.8 to 24.7%. Total protein per plant has ranged from 3.0 to 7.0 g per plant in the selected population, indicating genetic variability still exists for further improvement.

An added bonus has been found in these studies. We have found that higher protein content is a good indicator of higher dry matter digestibility, and therefore we have improved the nutritive value and utilization by selecting for high protein levels in alfalfa.

Title: Red Clover Improvement

Leader: J. A. Schillinger, Maryland

Improvement in red clover forage yields and stand persistence has been recognized in the recently released and recommended red clover variety Kenstar. This variety was evaluated in Maryland for 3 years. It showed superior forage yields to those of Chesapeake and Pennscott in tests conducted at Clarksville during 1968-1970. Stands of Kenstar persist 6-8 months longer than those of Chesapeake.

Also under evaluation in newly established tests is the first true double-cross hybrid red clover. The hybrid is being compared to standard varieties Chesapeake, Kenstar, Pennscott, and common medium red clover. In preliminary trials, the hybrid red clover has shown excellent vigor, recovery, and dry matter production.

Title: Breeding and Genetics of Bromus inermis

Leaders: G. M. Dunn, G. Y. Tan, and H. Lea, New Hampshire

Third-year yields were obtained on a brome grass variety test. The trend continued for decreasing differences between syn 1 and syn 2 yields; in 1972, syn 1 yielded 5.31 tons/ha compared with 5.27 tons/ha in syn 2. Blair and Saratoga were the leading check varieties and did not differ significantly from the better synthetics. In a trial seeded in 1971 Fox, Blair and Saratoga were superior to Polar and Carlton; average yields in this trial were 7.6 tons/ha compared with 5.2 tons/ha in the 1969 test, although stands were still excellent in the latter and there was no deficiency of moisture or fertility.

Normal 8N varieties apparently differ significantly in stomatal frequency and size on both leaf surfaces. Diallel analyses are being completed for stomatal and growth characteristics in the species. Additional studies are in progress relating stomatal and other leaf characteristics to photosynthetic activity.

Title: Breeding and Genetics of Birdsfoot Trefoil

Leader: H. M. Schaaf, USDA-ARS, Cornell

None of 11 Syn-3 trefoils, tested over 3 years (1970-72) and 5 locations in the Northeast, were significantly different from Viking and Maitland in forage yield. Diallel crossing of the agronomically superior parent clones revealed wide differences among them in cross-compatibility--a situation tending to restrict synthetic parentage and conducive to excess inbreeding in advanced generations. Such evidence indicates the need to consider compatibility relationships as well as agronomic traits in formulating trefoil synthetics.

Modifications of the picrate test have consistently differentiated G+E- plants (those containing cyanoglucoside but lacking glucosidase activity) from G-E+ and G-E- plants. The modifications eliminate the need for the glucoside and enzyme extracts used for the same purpose in other species. Such extracts are difficult to handle in trefoil, owing to its high tannin content.

Use of the new technique showed that acyanogenesis in selected trefoil clones was the result of low glucosidase activity and not low cyanoglucoside content as was previously assumed. BC-1 ratios indicate that trefoil clones used in previous genetic studies, assumed to be homozygous, are at best triplex at one or the other of the two loci governing the cyanophoric character. Studies comparing parents and F_1 's as to rate and amount of HCN-release suggest that dominance is lacking at both loci.

VN-2 trefoil, released in 1970 as an acyanogenic genetic marker stock, has shown high seed-yield potential in tests conducted in the Champlain Valley.

Title: Breeding and Cytogenetic Investigations and Improvement of Cool Season Perennial Forage Species

Leaders: R. P. Murphy and C. C. Lowe, New York (Cornell)

Breeder seed has been produced for increasing an alfalfa synthetic that combines the growth characteristics of the variety Saranac with resistance to southern anthracnose. The new variety was developed from the USDA germplasm release, Beltsville 2 An-4. Additional selection was made for anthracnose and bacterial wilt resistance and field testing was done to establish that winter hardiness is comparable to that in the parent variety. This variety is intended for use in southeastern New York and adjacent areas of the NE where anthracnose is a factor in production.

Preliminary seed increases are also in progress for a Saranac-type variety with higher yield capability and a synthetic expressing the multifoliolate leaf characteristic. Other experimental synthetics derived from various exotic germplasms are under evaluation for forage productivity.

An alfalfa field nursery has been established at Valatie, N.Y. for selecting resistance to the alfalfa blotch leaf miner, Agromyza frontella. This is a new and potentially destructive insect pest on the crop.

Development of inbred lines of alfalfa as parents for synthetics or hybrids was continued. S₄ lines from the variety Saranac are being produced from field-selected S₃ plants. S₃ lines out of Iroquois were field planted in 1972 and will be selected for selfing in 1973.

A diallel cross series of clones with different combinations of leaflet number and leaf/stem ratio is now being studied with a vitro digestion procedure to determine how these morphological features influence heritable quality differences.

Breeder seed has been produced and commercial seed production is being evaluated for a medium-late maturity timothy variety. Evaluation trials have indicated higher feeding value potential and satisfactory cultural characteristics in comparison to varieties in use.

Title: Breeding and Cytogenetics of Alfalfa and Red Clover

Leaders: R. W. Cleveland, M. L. Risius, and J. S. Shenk, Pennsylvania

Alfalfa variety field trials begun under precursory project were continued. Locations of trials were in two Pennsylvania counties, one in Lancaster and one in Centre. Forage yield, disease, and stand longevity data were taken and analyses made. Performance data, accumulated for two or more years, have revealed several superior varieties which we recommend for farm use. Trials in southern Pennsylvania have shown the importance of anthracnose disease, for which resistance in several varieties has been found. The highest levels of resistance were found in four experimental varieties developed by the USDA (Beltsville, Md.). Two of the experimentals are expected to be released soon and become available for commercial use.

We have continued breeding our own alfalfa materials for anthracnose resistance. Progenies produced in 1972 will be grown in Lancaster Co. for field evaluation of disease and agronomic traits. Red clover developed by us for resistance to northern anthracnose and other diseases is also being evaluated under field conditions.

Breeding creeping-rooted alfalfa was continued. Nurseries of plants to be evaluated in 1973 were maintained. New selections were made and will be used as parents for new generations. Disease evaluations of creeping stocks are planned in future work.

Title: Breeding Crownvetch for Forage and Slope Stabilization Usage

Leaders: M. L. Risius, J. S. Shenk, and R. W. Cleveland, Pennsylvania

Fifty plants randomly selected from Coronilla varia L. cv. Chemung (crownvetch) were used in a nested mating design to estimate genetic components of variance assuming autotetraploid inheritance. The five characters studied over a 2-year period were forage yield at first and second harvest, total forage yield, and plant height at first and second harvest. Estimates of total genetic variance were significant for all characters studied except forage yield at second harvest. Estimates of additive genetic variance were positive for each of the characters, but none exceeded their standard errors. None of the estimates of digenic or trigenic variance were significant. Quadrigenic variance was the most important component of genetic variance for all characters studied and was significant for forage yield at second harvest and total forage yield. Heritability estimates were low for each of the characters.

Title: Breeding for Improved Forage Quality

Leaders: J. S. Shenk, R. W. Cleveland, and R. L. Cowan, Pennsylvania

Sixty-one individual orchardgrass plants were evaluated over a 2-year period to determine the relationships among plants for in vitro dry matter disappearance (IVDMD), protein concentration and morphological characteristics. Significant differences existed among plants for the rate of decline in IVDMD and protein concentration. Analysis of variance of the data obtained for each plant at 6 weeks first growth and 6 weeks regrowth revealed either significant harvest x plant or year x plant interactions for many variables. Low forage quality of first harvest was associated with stem production, but no simple morphological characteristic seemed to be associated with forage quality in the aftermath harvest.

Crownvetch plants in accession nurseries were evaluated over a 2-year period for early spring growth, plant height, vegetative production, recovery growth, flowering date and seed set. Forage from 265 superior

plant types was collected and analyzed for IVDMD. About 20% of these plants will be intercrossed to produce progeny for the next cycle of selection.

A study was initiated with crownvetch to investigate genotype-environment interactions involving plant constituents related to forage quality. Of the six plants selected, two plants were rated above average for IVDMD, two intermediate, and two below average. These plants were vegetatively propagated and planted in replicated trials in Pennsylvania, Maryland, Wisconsin, Virginia, West Virginia, and Georgia during 1972.

Title: Breeding of Perennial Forage Grasses

Leaders: J. S. Shenk, R. W. Cleveland, and M. L. Risius, Pennsylvania

Three populations (ABC) of individual orchardgrass plants have been established to begin a phenotypic recurrent selection program for improved forage quality. Thirty-one plants having consistently better than average forage quality over years and harvests were selected from population A and combined to produce the first cycle of selection. Population B, established in 1971, was screened for vigorous, disease-free plants. Forage harvested from superior plants will be analyzed for in vitro dry matter disappearance (IVDMD) and protein concentration. Several plants with exceptionally high resistance to rust were established in a crossing block to produce polycross seed for a rust resistant synthetic. A new nursery of approximately 3000 individual orchardgrass plants was established from plant introduction sources to constitute population C.

The influence of plant morphology and maturity on forage production and quality will be investigated in a new field plot trial containing 10 synthetics and 2 standard varieties. Three synthetics were derived from population A on the basis of morphological characteristics.

Six synthetics were continued from research of a previous regional project. They represent high yielding synthetics, but differ in maturity characteristics. The varieties Pennlate and Pennmead will serve as standards.

Title: Breeding of Improved Varieties of Forage Species Adapted to the Northeast

Leaders: J. S. Shenk, R. W. Cleveland, and M. L. Risius, Pennsylvania

Field evaluations of orchardgrass varieties synthesized in various ways were continued. A second round of trials was designed to find out whether certain crossing combinations of the clones of Pennlate and Pennmead cultivars would show significant differences in forage production. Pennsylvania, New York, and Maryland AES personnel are involved in experiments in which three types of single crosses and double-cross synthetics from Pennmead and Pennlate clones are being evaluated. These trials are expected to require three years for adequate evaluation. Data were gathered in 1972 for the first year.

The first round of orchardgrass trials with the same objectives had been completed in 1971. An analysis of data combined over years was accomplished. In brief, for both Pennlate and Pennmead clones, all synthetic combinations were not significantly different or had lower yields than the original conventional synthetics. The synthetic products tested were conventional synthetics, restricted polycrosses, single crosses, and double-cross synthetics. It was notable that significant differences in yields occurred among single crosses. In the test of Pennlate synthesis products the highest and lowest yielding entries were single crosses; so specific combining ability apparently was important in this material.

Title: Grass Breeding--Tall Fescue and Red Fescue

Leaders: J. J. Murray and F. V. Juska, USDA-ARS, Beltsville, Md.

Second-year performance data were obtained on replicated space plants of (a) 70 lines of tall fescue, (b) 84 lines of red fescue, and (c) 65 lines of bluegrass received from the Plant Introduction Station, Pullman, Wash. Next Spring, open-pollinated seed will be harvested from selected lines and individual plants for progeny tests in solid-seeded turf plots.

Polycross progeny from 97 tall fescue clones selected for their rhizomatous growth habit were space planted in a field nursery in the fall of 1971. The nursery was mowed at 3 inches during the 1972 growing season. The rhizomatous characteristic was expressed among progeny from only 16 of the 97 clones which indicates that selection for this character should be done with plants under close mowing. Studies will be initiated to investigate the rhizomatous growth habit of clones using different management programs as space plants and as sod.

Thirty-nine tall fescue clones were selected for fineleaf and crossed in the greenhouse in 1971. Polycross progeny from each clone were planted in a space nursery that fall. Correlation of leaf width scores taken on the progeny as seedlings in the greenhouse and as mature plants in the field suggest that selection for this character can be done in the greenhouse when plants are in the seedling stage of growth.

A total of 1560 polycross progeny from 78 red fescue clones and 20 plants from each of 26 cultivars were screened in the greenhouse for resistance to Helminthosporium sativum. When injury scores were taken on a scale of 0-9, with 9 being resistant, 23.1% of the polycross progeny and 30.3% of the plants from selections scored 8 or above. A few plants had no lesions and will be inoculated again to determine if they were escapes.

A progeny test of 29 selections of red fescue were seeded in 3 x 5 ft plots this fall.

Title: Seed Production by Lolium-Festuca Hybrid Derivatives in Muslin Covered Cages

Leader: C. C. Berg, Pasture Research Laboratory, University Park, Pa.

Plots containing 16 plants of each of four different clones of Lolium-Festuca hybrid derivatives were enclosed in muslin covered cages. In 1970 seed yields were compared when cages contained (1) no fans, (2) two 8-inch fans, and (3) two 8-inch fans and a dehumidifier. Seed yields averaged 0.38 g/plant when fans were not used. Fans with or without dehumidification resulted in highly significant increases in seed yields (1.15 and 1.61 g/plant, respectively). Clonal differences were large and highly significant.

In 1971 seed yields of the same plots were compared under (1) no cover, (2) muslin cover, and (3) muslin cover with two 8-inch fans. Seed yields under muslin were much lower than yields of plots without cover (0.5 and 4.16 g/plant, respectively). Fans had no effect on seed yield in muslin covered cages in 1971 (0.53 g/plant without fans; 0.48 g/plant with fans). Due to the unexplained yearly variation breeders cannot depend entirely on this type of isolation for seed increase of Lolium-Festuca hybrids.

Title: Continued Evaluation of Perennial Ryegrass

Leader: D. W. Allinson, Connecticut (Storrs)

A total of 74 perennial ryegrass cultivars, most of which were obtained from the Regional Plant Introduction Station at Geneva, N.Y., were set out in 10 ft rows in August 1972. Initial growth varied considerably, both in vigor and appearance. Though we had a very open winter with little snow cover and widely fluctuating temperatures, winter survival was excellent. Only one cultivar, P.I. 277845 (Cyprus), was completely winter-killed. Most cultivars made excellent and early spring growth.

Title: Red Clover Forage Yield and Stand Persistence Study

Leaders: A. M. Decker, Maryland and C. S. Garrison, USDA-ARS, Beltsville, Md.

Thirty-one Kenland, 10 Chesapeake, and 1 Kenstar entries were seeded at the Agronomy-Dairy Forage Research Farm on April 21 (reps 2-6) and April 28 (rep 1). Because of excessive rain, weeds were a serious problem, and no forage yields were taken during the seedling year. Plots were clipped twice for weed control, and all clipped material was removed. Two stand ratings were made in 1972, and a third in March 1973.

Excellent initial stands were obtained for all except five Chesapeake and one Kenland entry. The poor Chesapeake stands appeared to be more the result of seedling vigor than of initial germination, but data were not available to substantiate this fact.

Most stand ratings improved with each date; however, two of the Chesapeake entries changed very little. Seed storage conditions and location of seed production appeared to have a definite effect on plant vigor and stand density.

Title: Evaluation of Perennial Ryegrass and Ryegrass-Tall Fescue Hybrids as Forage for Northern Areas

Leaders: Glen M. Wood and James G. Welch, Vermont

Several ryegrass-tall fescue synthetics, perennial ryegrasses, and Kentucky 31 tall fescue were field planted in replicated plots in August 30, 1972. With the exception of the named ryegrass-tall fescue hybrid Kenhy all of the synthetics were characterized by low seedling vigor and zero to poor winter survival. The synthetics were obtained from the Pasture Laboratory and Kenhy was obtained from the Kentucky Agricultural Experiment Station. The outstanding perennial ryegrass was Norlea which had no winter injury. Common and Linn perennial ryegrass showed severe winter injury. Other ryegrasses in the test with good to excellent winter survival were Manhattan, Pennfine, Caprice, Pelo, Combi, Melle, Splendor, NK-100, Barenza and several unnamed selections. Both Kenhy and Ky 31 showed good winter survival.

In artificial freezing tests fair to good correlation was obtained between freezing results and those obtained in the field. The artificial freezing tests were more severe and resulted in greater injury, particularly to common perennial, NK-100, Combi, Melle and Pelo. Difficulties were experienced in obtaining uniformity of results in the artificial freezing tests and refinements are being worked on. All of the ryegrasses in the freezing tests received more injury than Park Kentucky bluegrass.

In vitro digestion studies of the ryegrasses in comparison with Kenhy, Ky 31 tall fescue, Pennmead orchardgrass, Climax timothy and Park Kentucky bluegrass showed that the ryegrasses were higher in digestibility when harvested in the pasture stage of growth.

SECTION II

ENTOMOLOGY RESEARCH

Title: Insect Pests of Forage Legumes

Leader: R. A. Byers, Pasture Research Laboratory, University Park, Pa.

Unsprayed plots of Vernal alfalfa had more pea aphids, Acyrtosiphon pisum, and less lignin and acid detergent fiber (ADF) than plots sprayed with insecticide in August 1971. The sprayed plots had less pea aphids, more lignin and ADF, and hence lower quality. The pea aphid infested plants were stunted with shorter stems, while sprayed plots had plants with longer, thicker stems.

Alfalfa weevil larvae, Hypera postica, were collected from the field and placed on corn-soybean-milk (CSM) agar diet. Of 165 larvae collected, 58 were parasitized by Blathyrpectes curculionis, 33 larvae reached the pupal stage, and 13 females and 9 males emerged. Length of time that the larvae were on the diet to pupation varied from 4-42 days.

Clover root borer adults, Hylastinus obscurus, were maintained on 3 artificial diets. The mean survival for 137 borers during a 113-day test period was 99 days for a wheat germ diet, 102 days for CSM, and 70 days for alphacel (control). Mortality was near 100% on the 113th day for the control diet, while mortality was less than 10% on the other 2 diets.

Title: Effect of the Alfalfa Weevil on Alfalfa Production and Physiology

Leaders: Gary W. Fick, Beverly Wen-Yuh Liu, and George A. Maybee, New York (Cornell)

Cooperators: B. E. Dethier, C. C. Lowe, and R. G. Helgesen

Yield, leaf percentage, in vitro dry matter disappearance (IVDMD), and total nonstructural carbohydrates of taproots (TNC) are being used to determine the immediate and long-term effects of the alfalfa weevil on the production, feed quality, potential regrowth, and winter survival of alfalfa. In the field trials of 1971 at Aurora, weevil feeding reduced

the seasonal dry matter yield by 1.73 MT/ha. The measured peak larval population was 2.68/stem or 1120/m² on June 14. We could not measure an effect of the weevil on hay quality by changes in either leaf percentage or IVDMD on the cutting dates though differences did occur during the first regrowth period. The rate of accumulation of TNC was slowed during the period of peak feeding in mid-June if the alfalfa was not cut. If the alfalfa was cut before the period of maximum insect feeding, the same kind of response was observed, but it was delayed until early July when rapid TNC accumulations associated with the advanced stages of regrowth were taking place. By this time, larval feeding had essentially ceased. The indirect effect of the alfalfa weevil on yield, operating through TNC levels in the roots, appeared to be an important component in the total effect on yield.

These trials were repeated in 1972 and the root and forage samples have not yet been analyzed. The measured peak larval population was 1.09/stem or 699/m² on June 14. There was no seasonal reduction in yield that could be attributed to weevil feeding. Since experimentation in the field is difficult because of a highly variable and unpredictable alfalfa weevil population, we have initiated hand defoliation studies in the greenhouse using defoliation patterns based on detailed studies of the amount and duration of feeding by the alfalfa weevil.

SECTION III

PLANT PATHOLOGY RESEARCH

Title: C-Glycosyl Flavones in Crownvetch

Leader: R. T. Sherwood, Pasture Research Laboratory, University
Park, Pa.

Flavonoid compounds were identified for the first time in crownvetch hay. These included six 6-C-glycosylflavones, viz., isoorientin (I), isovitexin (II), the 4'-O-glucosides of I and II, the 7-O-glucoside of I, and the previously unknown 2''-O-rhammoside of I. Four of the flavone C-glycosides occurred in cultivars Penngift, Chemung and Emerald harvested at three times. Total concentrations of flavones ranged up to 1.5% dry weight. The concentrations of individual compounds did not vary greatly between cultivars within harvests, but varied significantly between harvests of a given cultivar. There was wide variation in flavonoid content between individual plants within a spaced planting, indicating the possibility of breeding for varieties having high or low content of these usual compounds. In preliminary bioassays, 800 µg/ml of II, but not of I, completely inhibited spore germination of Stagonospora arenaria, Fusarium roseum, Colletotrichum trifolii, and Ascochyta imperfecta (which do not infect crownvetch leaves), but not Stemphylium botryosum (which does infect the leaves).

Title: Anthracnose of Forage Legumes

Leader: F. L. Lukezic, Pennsylvania

Colletotrichum trifolii can persist from one harvesting season to another on the surfaces of protected alfalfa harvesting equipment. The fungus was able to survive in alfalfa stems for only 100 days under the field conditions tested. This suggests that under Pennsylvania conditions, infected plants can be important sources of secondary inoculum, but may not be important as a source of primary inoculum. Anthracnose was shown to be important in predisposing the infected plants to winter injury.

Colletotrichum destructivum O'Gara was isolated from diseased crownvetch on a highway slope in Pennsylvania. The diseased plants exhibited stem

lesions and necrotic leaflets. Greenhouse grown crownvetch was inoculated with spore suspensions of C. destructivum, symptoms developed and the pathogen was reisolated constituting the first proof of pathogenicity of C. destructivum on crownvetch.

Title: Field Performance of Anthracnose Resistant Alfalfa Populations in Maryland

Leaders: T. E. Devine, USDA-ARS, Beltsville, Md.; J. A. Schillinger, Maryland; and C. H. Hanson, USDA-ARS, Beltsville, Md.

Anthracnose resistant populations developed by recurrent phenotypic selection in the laboratory and greenhouse at Beltsville, Md. were evaluated in broadcast plots in Maryland tests. The resistant selections developed in the laboratory were highly resistant to naturally occurring anthracnose epiphytotics in the field. The resistant selections were markedly superior to the susceptible parental populations from which they were developed in three field tests. After two harvest years they averaged 35% greater cover, 37% less weed encroachment, and twice as many plants per unit area.

Title: Alfalfa Management and the Incidence and Severity of Disease

Leaders: F. L. Lukezic and J. B. Washko, Pennsylvania

Influence of clipping height on neutral carbohydrate levels in root exudates of alfalfa grown gnotobiotically was investigated by gas-chromatographic and mass-spectral techniques. Exudates were obtained from plants that were lightly clipped (removal of flower buds), intermediately clipped (15 cm), and severely clipped (removal of all but four mature leaves). Glucose, inositol, sucrose, and four unidentified (U) components were detected. Fluctuations in the level of sugars were observed in exudates from two sampling periods. Glucose and U₁ were most concentrated under light clipping. Levels of inositol and sucrose were maximum under intermediate clipping. Amounts of U₃ were greatest from severely clipped plants, whereas levels of U₅ remained constant at all cuttings. Concentration of U₄ was lowest under severe clipping. U₂, present in exudates from seedling plants, was not detected. Quantities of sugars released per gram of dry weight of root tissue were greater under severe clipping. U₁ was the major component, with glucose, inositol, and sucrose minor components of the total sugars.

Title: Aspects of Wilt of Alfalfa Caused by Corynebacterium insidiosum

Leader: F. L. Lukezic, Pennsylvania

The effect of 4 inoculum concentrations (5.5×10^7 , 11×10^7 , 22×10^7 , 44×10^7 cells/ml) of Corynebacterium insidiosum on symptom development in semiresistant and susceptible alfalfa cultivars was studied. Inoculum concentration of 11×10^7 and 22×10^7 cells/ml was optimum, causing maximum response in symptoms in cv. DuPuits and cv. Buffalo, respectively. The semiresistant Buffalo required nearly 4 times the cell/ml to produce response in symptoms similar to those produced in susceptible DuPuits. Inoculum concentrations higher than those optimum for symptom development for each cultivar, reduced the response instead of causing a progressively more severe response in general symptoms and leaf size reduction. A reduction in top fresh weight and chlorophyll content of leaves occurred with increase in symptom severity.

Title: Leptosphaerulina briosiana on Alfalfa: Relationship of Lesion Size to Leaf Rank and the Effect of Light Intensity on This Relationship

Leaders: K. T. Leath and R. R. Hill, Jr., Pasture Research Laboratory, University Park, Pa.

A relationship of the size of lesions caused by Leptosphaerulina briosiana to the position of an alfalfa leaf on the stem was established in greenhouse and growth chamber tests. Lesions on the uppermost leaf were the largest and decreased in size on the next three successively lower leaves. A similar gradient in lesion size was observed in three susceptible clones with two fungal isolates, but not in two resistant clones. The gradient in lesion size was greater under high ($21,528 \text{ lumens/m}^2$) than under low (9688 lumen/m^2) postinoculative light. The large, susceptible-type lesions occurred only under the high light condition. A lesion size gradient occurred in high light even when stems were held horizontally, so that all leaves received essentially the same amount of light energy. Plants that did not have a gradient in lesion size also did not produce pale green, succulent leaves at the top of the stem. Postinoculative light of $21,528 \text{ lumens/m}^2$ or greater and vigorously growing plants are prerequisite to selection for resistance to L. briosiana.

Title: Selection for Disease Resistance in Alfalfa

Leaders: R. R. Hill, Jr., K. T. Leath, K. E. Zeiders, Pasture Research Laboratory, University Park, Pa.; and W. L. Haag, Pennsylvania

Theoretical and experimental comparisons of the relative effectiveness of individual, S_1 and polycross progeny test, and S_1 and polycross family selection were compared for resistance to Uromyces striatus, Stemphylium botryosum, and Phoma herbarum (see 1970 Annual Report, p. 13). The theoretical comparisons indicated that selfed progeny test and selfed family selection should be among the most effective methods. The rank of the remaining methods studied, in order of theoretical effectiveness, was polycross progeny test, full-sib family, individual, and half-sib family selection. Full-sib family selection was not compared experimentally. Each of the methods gave a significant increase in resistance to U. striatus. S_1 progeny test, S_1 family, and individual selection were the most effective methods, polycross progeny test and polycross family were least effective. The family and progeny test methods were more effective than individual selection, but were not significantly different from each other in selection for resistance to P. herbarum. No method gave a significant increase in resistance to S. botryosum.

The first cycle of selection in an experiment to compare the long-term effects of individual, half-sib family, full-sib family, and alternating S_1 family with full-sib family selection was completed. The first cycle of selection to increase resistance of MSE and MSF alfalfa to Pseudopeziza medicaginis was completed.

Title: Resistance Mechanisms Associated with Foliar Infections of Forage Crops

Leader: R. L. Millar, New York (Cornell)

A second phytoalexin was isolated from inoculated alfalfa leaflets. This second compound is closely related to medicarpin ((3-hydroxy-9-methoxy-pterocarpan)). The second compound has been characterized and identified as R-(-)-7-hydroxy 2',4'-dimethoxy-isoflavan and has been assigned the trivial name, sativin. Sativin is produced in much higher concentrations and has markedly higher antifungal activity than medicarpin which suggests that it may have an important role in disease resistance of alfalfa leaf tissues.

Two phytoalexins produced by birdsfoot trefoil leaves in response to inoculation have been characterized as sativin and vestitol ((-)-7,2'-dihydroxy-4'-methoxyisoflavan). Both compounds have high antifungal activity. Stemphylium loti, a pathogen of trefoil, has the capacity to degrade both compounds.

An investigation of the degradation of medicarpin and sativin, by the alfalfa pathogen S. botryosum, has indicated that the first and principal product of medicarpin degradation is vestitol; the degradation products of sativin have not yet been characterized.

Compounds closely resembling and probably identical with medicarpin and sativin have been recovered from white clover and sweet clover, respectively.

Host and pathogen (S. loti) enzymes involved in cyanogenesis in diseased birdsfoot trefoil leaves have been purified and characterized. Diseased tissue yielded only pathogen β -glucosidase.

Title: Selecting Resistance to Helminthosporium dictyoides in Lolium-Festuca derivatives

Leaders: R. T. Sherwood, K. E. Zeiders, and C. C. Berg, Pasture Research Laboratory, University Park, Pa.

Fifteen clones derived from Lolium-Festuca hybrids differed significantly in net blotch severity in a field planting at each of two harvest dates and in four greenhouse inoculation tests with Helminthosporium dictyoides. With two exceptions the greenhouse tests were correlated with one another. Field tests were not correlated with each other or with any greenhouse test. Another set of 5 clones differed consistently at both times of scoring in the field and in one greenhouse test but appeared equally susceptible in another greenhouse test. Although scores between tests were variable for most clones, scores for two of the clones were consistently low in all tests.

Title: Reaction of Orchardgrass Cultivars to Purple Leafspot
Caused by Stagonospora arenaria

Leaders: K. E. Zeiders, R. T. Sherwood, and C. C. Berg, Pasture Research Laboratory, University Park, Pa.

Twenty-eight cultivars of orchardgrass (Dactylis glomerata L.) were screened for their reaction to a single isolate of Stagonospora arenaria Sacc. in two inoculation tests. Using a scale of 1 to 8 to rate severity of purple leafspot, the overall disease means ranged from 3.97 to 5.90. Differences in disease severity among cultivars were highly significant for both inoculations. There was a significant interaction between replications and inoculations, but the interaction of cultivars with inoculations was nonsignificant. Mean disease severity ratings were lower for the second than for the first inoculation. No plants were rated "1" (disease free) or "8" (very severely diseased). None of the cultivars exhibited a high level of resistance to purple leafspot. There was, however, considerable variation among cultivars in percentage of plants with low disease ratings of "2" or "3." The resistant reaction of these plants was verified in a third inoculation in which selected plants of all cultivars had lower mean disease ratings than unselected control plants.

SECTION IV

GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS

Title: Forage Physiology, Morphology, Growth, and Utilization

Leaders: G. E. Carlson, N. J. Chatterton, R. H. Hart, USDA-ARS,
Beltsville, Md.

Accumulation of assimilates within the leaves of several forages produced a feedback-inhibition of photosynthesis, and may restrict plant yield below its potential. Tiller induction and formation appeared to stimulate massive mobilization of nonstructural carbohydrates. Data suggest that tiller initiation late in the fall coincides with and, in fact, may stimulate an accumulation of nonstructural carbohydrates in the roots. Furthermore, since increased root reserves are correlated with winter survival, tillering may be an important selection criterion for winter hardiness.

A model of the relationships among forage yield, stocking rate, and beef gains on pasture was developed; this is the first such model published. If economic parameters are inserted, as suggested in the published article, the model will become a reliable guide to more profitable pasture management.

Photosynthesis, morphology, and yield in the field of 120 alfalfa clones were studied. Tiller number was the only measurement which was significantly correlated with yield. Photosynthesis, specific leaf weight, and the increase in specific leaf weight during the day (a measure of assimilate accumulation in the leaf) were not correlated with yield. Weight of the largest tiller on each plant was not correlated with the product of photosynthetic rate and leaf area on that tiller. Winter survival and specific leaf weight were positively correlated with photosynthetic rate.

Title: Environmental Studies with Plants

Leaders: A. M. Decker and J. M. Walker, Maryland

Funk corn varieties (17-A, 4550, and 5757) were grown in field plots at soil temperatures of 16 C, 24 C, 32 C, and ambient. Plots were uniformly fertilized with 224, 99, and 372 kg/ha of N, P, and K. respectively. Plants, at a uniform 2-leaf stage, were transplanted into the field at a

population of 77,511 plants per hectare. A uniform 5-cm straw mulch covered all plots to help maintain desired soil temperatures. Temperature plots were individually irrigated to maintain "uniform" soil moisture. The experimental design was a split plot with three replications. Whole plots were soil temperature, and varieties were sub-plots.

Weekly measurements were made of plant height and leaf development. Tasseling, silking dates, and other developmental data were recorded. Plots were harvested at mid to late dent (grain 30% moisture) and dry matter determined for various plant components.

Soil temperature had a marked effect on the rate of plant development and final yield. Corn varieties responded differently to soil temperature extremes. Cold soil temperatures reduced plant growth and final yield more than above-normal temperatures. Best yields were at ambient soil temperatures for all varieties.

Title: Effects of Slope Exposure on Microclimates and Growth of Grasses and Legumes

Leaders: M. A. Sprague and J. Daddario, New Jersey

Major differences between north and south facing slopes were observed in air and soil temperature, soil moisture, solar radiation, rainfall, and relative humidity. Many differences were hourly or diurnal such as air temperature, solation and relative humidity. Many were seasonal. Others were accumulative; such as soil moisture, rainfall and soil temperatures.

Rainfalls were greater on west and north slopes in summer and on north and east slopes in spring and fall. The south-facing slope consistently received the least rainfall. Solation and air temperatures were highest on southern slopes and least on north slopes and these differences were greatest at the winter solstices. Soil moisture (a function of evaporation, precipitation and transpiration) was limiting to plant growth much of the season on south slopes and never below wilting points on north slopes. Air and soil temperatures on east facing slopes were higher than those facing west. Plant growth reflected the observed climatic differences. Carbohydrate reserve levels in orchardgrass were monitored as winter dormancy broke in March.

A new device is being developed for use in measuring relative humidity in small spaces such as under leaves. Preliminary data indicate dramatic differences in RH during daytime hours on different slopes and in different plant covers. Tests are anticipated for their relationship to incidence of disease, insects, effectiveness of herbicides as well as plant growth patterns.

Title: Morphology, Physiology and Cultural Response of Perennial Forages

Leaders: J. J. Faix, G. W. Fick, R. R. Seaney, and M. J. Wright, New York (Cornell)

Alfalfa, birdsfoot trefoil, and crownvetch were grown at 17, 22, 27 and 32 C to determine the effect of temperature on forage quality. Leaf-stem separations and division of stems into internodal sections were made to detect temperature induced changes in IVDMD, NDF, ADF, and lignin levels. Only the IVDMD analyses of alfalfa are completed. High temperature increased whole plant IVDMD. The increase was not due to any change in IVDMD in the plant parts but was mainly due to greater leafiness.

Studies were concluded on the effect of seeding year harvest management on forage yields of alfalfa. In general less intensive harvest management in the seeding year, late first cut and 8-week intervals between cuts, resulted in higher yields the second year. However, differences between seeding year cutting treatments were much smaller the third and fourth harvest years. Results suggest that early spring seedings of Saranac and Iroquois can be harvested 10 to 12 weeks after planting and subsequent harvests made at 6 to 7 week intervals.

Fall irrigation of alfalfa was used to study the effect of water logged soil in the autumn on winter survival and subsequent yield over five fall cutting dates. No significant effect could be attributed to cutting date or its interaction with irrigation, but fall irrigated plots were lower in population (102 vs. 121 plants/m²; P = 10%) and in first cutting yield (4.0 vs. 6.0 MT/ha at 15% m.c.; P = 5%), the following spring. In order to study the interference of water logging under controlled conditions with field grown plants, methods of transferring taproot-and-crown sections from the field to nutrient solution culture were investigated.

Title: Thatch Formation in Kentucky Bluegrass

Leaders: F. V. Juska and J. J. Murray, USDA-ARS, Beltsville, Md.

An area 240 ft x 60 ft was seeded to common Kentucky bluegrass in September 1963. Plots were mowed weekly at 2-inch height. Treatments began in 1964 and were repeated through 1972.

Split-split plot design was used for this study (a) clippings, removed and not removed; (b) three pH levels--5.5 control, lime to pH 7.0, and lime annually 10-15 lb/1000 sq ft spring and fall; (c) other--aerify (Ryan), handrake, wetting agent, control, verticut (Henderson and Jacobson), and the addition of organic material.

Two-inch cores, five from a plot, were removed in January 1966, 1968, and 1969 but did not show any significant difference in thatch accumulation. With respect to turf quality, the aerification treatment showed a significant increase. Two-inch plugs were obtained in 1970, 1971, and 1972.

The aerification treatment produced turf that was significantly higher in quality early in the study and continued through 1972. Lime applied to obtain a pH of 7 and lime annually did not significantly reduce thatch until 1972. Permitting clippings to remain on the plots significantly increased thatch accumulation only in 1971. Quality notes taken in September 1972 showed highly significant differences for both annual lime applications and lime to pH 7 and for the aerification treatment.

Title: Winter Injury and Persistence of Cool-Season Grasses

Leader: G. A. Jung, Pasture Research Laboratory, University Park, Pa.

Winter injury estimates, averaged over clipping and fertilization treatments, ranged from less than 1% for reed canarygrass to 83% for two perennial ryegrass cultivars. Ky bluegrass and smooth brome grass were injured slightly more than reed canarygrass, whereas timothy and redtop sustained 12-18% winter injury. Injury values ranged from 14% (Masshardy) to 57% (Pennmead) for orchardgrass; from 20% (Fawn) to 48% (Kenwell) for tall fescue; and from 33% (Norlea) to 83% (Commercial) for perennial ryegrass. Clipping treatments and N fertilizer differentially affected survival of the grasses.

Title: Root Growth of Forages

Leader: W. A. Kendall, Pasture Research Laboratory, University Park, Pa.

Techniques were developed for culturing plants on slant-boards with perlite and for inoculating segments of the roots with species of Fusarium. The procedure will be used to characterize root growth and fungus resistance of the host as well as pathogenicity of the fungus.

Title: Electron Micrographs of Cool-Season Grasses

Leaders: G. A. Jung, Pasture Research Laboratory, University Park, Pa.;
and R. P. Zimmerer, Juniata College, Huntingdon, Pa.

Electron micrographs showed that, in general, cell-wall thickness decreased with increasing levels of applied N. Cell walls of Masshardy orchardgrass leaves at heading were nearly twice as thick with zero N as with 120 kg N/ha. Cell walls of orchardgrass leaves were considerably thicker than those of tall fescue, reed canarygrass and perennial ryegrass. Cell-wall thickness did not vary with advance in growth stage. Chloroplasts of leaves grown at the zero rate of N generally tended to be smaller than chloroplasts of leaves at 60 or 120 kg N/ha. Starch grains in chloroplasts of plants grown at zero and 60 kg N/ha appeared to be more numerous and substantially larger than starch grains from plants at 120 kg N/ha. Chemical analyses indicated that percent starch varied from 1.01 to 7.91 in selected samples. In vitro studies showed that in 12 hr rumen microorganisms penetrated and proliferated most rapidly in Pennfine perennial ryegrass tissue, whereas few, if any, microorganisms could be found in the cells of reed canarygrass and tall fescue.

Title: Nonstructural Carbohydrate Concentrations in Grasses

Leaders: G. A. Jung and C. F. Gross, Pasture Research Laboratory,
University Park, Pa.

Nonstructural carbohydrate (CHO) concentrations in grasses ranged from 4 to 40% and varied with species, cultivar, growth stage, season, and rate of applied N. CHO levels, summarized over cutting and fertilization treatments, were 69% higher in spring and autumn than in summer. Perennial ryegrass contained 48% more CHO in spring and 37% more over the entire growing season than Ky bluegrass. Warm-season grasses appeared to have low CHO levels (about 8-10%) regardless of season of growth stage.

Nonstructural carbohydrate concentrations in six cool-season grasses clipped at 21-day intervals at Arthurdale, W.Va. decreased an average of 58% from April 26 to July 1. Carbohydrate concentration was considerably higher in smooth brome grass and timothy than in Kentucky bluegrass. A comparison of carbohydrate concentration in the tops of the six grasses previously clipped at different intervals showed that carbohydrate concentration was not greatly different for these treatments even though growth stage on June 10 varied from a leafy-vegetative stage to the full-bloom stage. Temperature was favorable for plant growth under these conditions.

Title: Cold Tolerance Studies with Forage Species

Leaders: G. A. Jung, Pasture Research Laboratory, University Park, Pa.;
M. Krasnuk and F. H. Witham, Department of Biology, The
Pennsylvania State University

Polyacrylamide disc gel electrophoresis studies involving amido black staining and densitometry revealed quantitative protein differences between cold-tolerant and cold-sensitive cultivars of Medicago sativa and between conditions favorable and unfavorable for hardening.

Multiple forms of peroxidase, IAA oxidase, polyphenol oxidase, dehydrogenase and several hydrolytic enzymes exhibited quantitative and qualitative differences.

SECTION V

WEED INVESTIGATIONS

Title: Alfalfa Establishment with Various Herbicides

Leaders: T. M. Good and J. A. Balasko, West Virginia

Seven herbicides and compatible mixtures of these chemicals were used to determine the effectiveness of herbicides in establishment of alfalfa. Six of the herbicides were labeled and one was an unlabeled experimental. Four of the herbicides were pre-plant incorporated (Eptam, Balan, Vernam, and Geigy 10832) and the other three were applied post-emergence (DNBP, 2,4-DB, and Dowpon). The labeled chemicals were used at the rates indicated on their labels. Whenever two herbicides were used together at the same time of application, the rates were one-half that recommended on the labels. Full strength was used where a combination pre-plant and post-emergence treatment was applied. The experimental pre-plant was used alone at three different rates. Data recorded to evaluate the effectiveness of herbicides were: percent ground cover, percent stand, number of alfalfa plants/ft², number of broadleaf and grass weeds/ft², alfalfa height and yield.

Significant differences were found between no treatment and various herbicide treatments. In order to make a more definitive evaluation of the herbicides used, the experiment will be repeated in 1973 at two more locations, one with a medium textured soil and the other with a light textured soil.

Title: Glyphosate for No-Tillage Silage Corn in Perennial Grass Sod

Leaders: R. A. Peters and W. M. Dest, Connecticut (Storrs)

Glyphosate gave nearly complete kill of Dactylis glomerata, Agropyron repens, and Taraxacum officinale from applications of 1, 2 or 4 lb/A when applied in April or May without injury to corn planted with a no-tillage planter. Activity was distinctly greater than with paraquat especially in the April application. As compared to paraquat plus atrazine as a standard treatment, statistically greater or comparable silage corn yields were obtained with all treatments with glyphosate,

simazine 4 lb in April, cyprazine 4 lb in May, paraquat plus cyprazine 1/2 + 2 lb in May, and atrazine plus weed oil plus 2,4-D at 2 + 1 qt + 1/2 lb/A in May. In no-tillage comparisons of triazines in controlling crabgrass (*Digitaria* spp.), simazine 3 lb or atrazine plus simazine 1 + 2 lb ai/A gave much better control than alachlor plus atrazine 2 + 1 lb ai/A or atrazine plus simazine 1.2 + 1.2 ai/A.

Title: Weed Control in Pastures and Forage Crops

Leaders: D. L. Linscott and R. D. Hagin, New York (Cornell)

Glyphosate, a new herbicide killed Agropyron, Dactylis, Phleum, Poa and most annual weed species. Weed control was best with glyphosate when applied at advanced stages of plant growth. Glyphosate shows promise for renovating pastures, establishing cover for erosion control, weed control prior to establishing legumes and no-till Zea. Glyphosate was superior to paraquat in controlling all weeds examined except Cyperus. Sub-lethal doses of glyphosate increased numbers of Cyperus tubers. Glyphosate-simazine combinations controlled Coronilla for 75 days in no-till Zea after which the legume spread and protected the soil surface. Zea yield reduction from legume competition was acceptable. Glyphosate killed Medicago and Lotus after a stubble treatment for weed control. Coronilla established successfully for seed and pasture because weeds were controlled by EPTC or benefin soil incorporations followed by between row applications of simazine or bromacil at planting or dinoseb post emergence. 2,4-D resistant Lotus strains metabolized 2,4-D more readily in roots than susceptible strains. C¹⁴ from ring labeled 2,4-D moved readily from Bromus roots into the leaves, but not from leaves to roots. 2,4-D side chain labeled C¹⁴ moved from both root and leaves. Leaf metabolism of 2,4-D side chain is indicated in Bromus. Bromus treated with 2,4-dichlorophenoxy crotonic ethylester reduced it to 2,4-DE ethylester. Both esters cleaved to an extent. After crotonic ester application 3-(2,4-DP) (>3 ppm) and 2,4-D (>3 ppm) were found.

Title: Weed Control Practices in Agronomic Crops in Relation to Crop Yields Herbicide Residues

Leader: W. B. Duke, New York (Cornell)

Crop rotation studies established to determine the effects of the use of the low residual herbicide pronamide (Kerb) on alfalfa yield and quality and on quackgrass (*Agropyron repens*) infestations have been completed. The use of 3 lb/A pronamide in the late fall (November) virtually

eliminated quackgrass as a competitive factor in established alfalfa throughout the following growing season. Similar rates applied in early April were not as effective. In the second year following the initial applications, quackgrass regrowth was significant regardless of rates of pronamide used. Regrowth could be prevented by a second application of 1.5 lb/A pronamide 12 months after the first application. Pronamide treatments significantly improved alfalfa yield the first year after application but not the second. No significant effects of the chemical on crop quality were noted.

SECTION VI

MANAGEMENT AND PRODUCTION RESEARCH

Title: Harvest Management of Crownvetch-Tall Fescue Mixtures

Leader: A. M. Decker, Maryland

Penngift and Chemung crownvetch were seeded with Ky 31 tall fescue. The experimental design was a split plot with four replications. Crownvetch varieties were whole plots, harvest frequency (3, 4, and 5 cuts) were sub-plots, and stubble heights (3.8, 6.4, and 8.9 cm) were sub-sub-plots. Uniform harvests were made in 1969. In 1970 and 1971, total forage yields and seasonal distribution of that forage, as affected by harvest management, were reported. In 1972 two uniform harvests were taken in order to measure residual treatment effects.

Chemung had largely disappeared from all treatments by 1972. Only at the late bloom stage (3 cuts) were there significant amounts of crownvetch. Penngift stands, on the other hand, were adequate on all but those treatments cut at the early bloom stage (4 cuts). Total forage yields generally paralleled the percentage of crownvetch in the sward. Volunteer white clover invaded some plots where the crownvetch component was low. There was a large plot to plot variability with regards to this clover invasion which complicated data evaluation.

Title: Establishment and Management of Several Grass and Other Species for Forage and Ground Cover

Leader: J. B. Washko, Pennsylvania

Band seeding with packer wheel drill, corrugated roller seeding, and surface seeding were compared for establishment of the legume, flat pea and the following warm season grasses, deer tongue, little and big bluestems, switchgrass and indiagrass.

The band seeding drill with packer wheels was superior to the corrugated roller-seeder and surface seeding by hand followed by cultipacking for the species listed. Stand establishment in a July seeding was most satisfactory for the flat pea, deer tongue and switchgrass. Of the four warm season grasses, little and big bluestems, indiagrass and switchgrass, best stands were obtained with switchgrass, irrespective of seeding method.

Title: Influence of Date and Timing of Nitrogen Applications on the Yields of Reed Canarygrass

Leader: D. W. Allinson, Connecticut (Storrs)

Initiated in 1971, this experiment evaluated four methods of nitrogen fertilizer application--(a) 100% spring applied, (b) 50% spring applied + 25% after each of the first and second harvests, (c) 25% spring applied, 25% after the first harvest, and 50% after the second harvest, and (d) 100% applied after the second harvest--on the yields of reed canarygrass. Three harvests were taken per year. Two rates of nitrogen, 200 and 300 lb N/acre, were used. The 2 x 4 factorial was set out in randomized complete blocks. Yields were taken in two years, viz., 1971 and 1972.

In both 1971 and 1972 both nitrogen level and method of application main effects were significant ($P < 0.01$). As expected, the higher nitrogen level resulted in increased dry matter yields. In both years split applications of nitrogen, i.e., methods (b) and (c) resulted in significantly increased yields compared to single applications of nitrogen, i.e., methods (a) and (d). The interaction between method and rate of nitrogen application was not significant in either year.

Title: Influence of N, P and K Fertilization on the Fall Growth and Composition of Ky 31 Tall Fescue

Leader: J. A. Balasko, West Virginia

In October 1971, an experiment was initiated to assess some of the quality aspects of fall-saved tall fescue forage. A split-plot design was employed with fertilizer treatments as whole plots and winter cutting management as sub-plots. N, P, and K were applied in factorial combinations, resulting in 7 fertilization treatments plus the control treatment. N was applied at the rate of 60 kg/ha in early spring and after each of three summer cuttings. No N was applied following winter harvests. P and K were applied at the rate of 30 and 60 kg/ha, respectively, in spring and fall. Winter harvests were made in mid-December and in mid-January. The last summer cutting in 1971 was made in mid-August.

One year's data have been summarized from this experiment. In the first year of the study, P and K fertilization had no significant effect on yield of forage. N fertilization increased annual yield from 3.7 to 10.3 m T/ha and the 1972 mid-December forage yields from 1.1 to 3.0 m T/ha.

Forage accumulated from October 5 to mid-December or mid-January of 1971 contained adequate concentrations of protein (above 12.2%) for beef cows. Mg concentrations in the forage were increased by N fertilization for both the mid-December and mid-January cuttings. The Mg concentration in forage harvested in mid-January, however, was below the 0.2% often cited as a critical level. Concentrations of most mineral elements in the forage decreased as harvest was delayed from mid-December to mid-January. Unexpected results obtained from this study were that TNC concentrations in the forage were increased as harvest was delayed from mid-December to mid-January and that forage obtained from high N plots had higher TNC percentages than those from low N plots.

Title: Productivity and Quality of Fertilized Perennial Forages

Leader: L. F. Marriott, Pennsylvania

Application of various rates and combinations of P, K, and Mg was made in the fall of 1971 on a 1970 seeding of crownvetch. Spring growth was very slow, attributed partly to the late (October) harvest in 1971 and to the cool wet spring. Herbicide was applied twice to control a serious infestation of Canada thistle. No harvest was made because of some herbicide damage and variability in growth of the crownvetch not related to treatments. The stand and growth of crownvetch along what may be a limestone ledge was much superior to adjoining areas. Soil tests indicated a higher pH and a 30% Mg saturation of the CEC in the good area compared with 6% Mg saturation in adjoining areas.

Orchardgrass, brome-grass, timothy and tall fescue were seeded in late April in established crownvetch with a packer wheel drill. Growth of the grasses was limited because of shading, but observations in October indicated a good stand of orchardgrass and a fair stand of the other grasses. Crownvetch continued to persist in the grass associations established in 1972, providing 5 to 20% of the harvested forage. There was generally a greater proportion of crownvetch with the tall fescue than with the other grasses.

A spring seeding was made of alfalfa, crownvetch, orchardgrass, brome-grass, timothy and tall fescue, and associations of crownvetch with each of the grasses. These plots will be used for fertility studies and to assess the contribution of crownvetch in the various associations.

Title: Mineral Composition of Various Forage Species Grown on Different Soils and Under Several Climatic Conditions

Leaders: Barton S. Baker, and R. L. Reid, West Virginia

During the 1971 and 1972 growing seasons, over 30 different forage and weed species were collected from 17 different soils and analyzed for mineral composition. Weather data regarding temperature and precipitation were also collected at each location.

The forage species have been found to vary greatly in mineral content. Phosphorus varied from 0.12 to 0.91% and magnesium less than 0.01 to 0.96% among the forage species collected in 1971. Similar values were obtained in 1972. Phosphorus values varied in the soils from 6 to 52 ppm and magnesium varied from 48 to 324 ppm. The level of a particular mineral in forage appears to be related to the plant species, soil level of that mineral, climatic conditions, and other factors.

Title: Changes in Plant Species and Production of Hill Pastures Due to Clipping, Lime and Fertilizer Application

Leaders: Barton S. Baker, Daniel E. Brann, and Doyle E. Harsh, West Virginia

Several permanent pastures were fertilized and limed according to soil test recommendations and clipped when the forage reached a height of 10 to 20 cm. Pasture cages were used to protect the areas from grazing animals. At each clipping the percent desirable species was determined. Some of the forage is being evaluated for feeding value.

Some areas which produced 1120 kg of forage per hectare in 1971 produced over 4480 kg of forage in 1972 with the application of lime and phosphorus. The percent desirable species has changed from 0 to 60% without reseeding. Other pastures with higher initial level of production have had yield increases from 14 to 224% and the percent desirable species has remained unchanged or increased as much as 80%.

Title: Plant Response to Soil pH

Leaders: R. W. Duell and A. J. Palazzo, New Jersey

An attempt was made to characterize the response of 19 grass and legume varieties to soil pH ranging from pH 4.2 to 7.6 in field plots of a Freehold sandy loam. Different pH levels were developed over a period of 4 years as a consequence of surface application rates of NH_4NO_3 and $\text{Ca}(\text{OH})_2$. Magnesium was also included as a variable. Four years later rows of the 19 entries were sown across these plots.

Nitrogen treatments depressed soil pH to a depth of 60 cm, and lime treatments increased pH to a depth of 40 cm. Soil tests indicated medium to high values for P, K, and Mg in spite of pH variation. All plants tested, except the red fescues, grew better where lime was applied. The red fescues generally produced their greatest weights at the lowest pH, viz., 4.2. The weights of Pennlawn and Highlight red fescues showed significant negative correlations with soil pH, while all other grasses and legumes had quadratic or curvilinear regression values. The Kentucky bluegrass, and perennial ryegrass varieties, C-26 hard fescue, and K-31 tall fescue produced best at pH 6.0-6.5. The legumes attained their maximum weight near neutrality, and were completely retarded on the most acid soil. The perennial ryegrasses tended to grow better where Mg was added, while the Kentucky bluegrasses and red fescues had higher weights without Mg.

Pennlawn red fescue, which did well in plots of very acid soils, had lower contents of aluminum in aboveground tissue than did certain other grasses that were limited in the more acid soil. Tissue contents of Mn and other nutrient elements appeared neither too high nor too low to limit growth.

Title: Pasture Production on Low pH Soils When Subjected to Various Combinations of Renovation, Fertilizer, Lime and Legume Seed

Leader: Barton S. Baker, West Virginia

Two soils (a sandstone and limestone) with pH's of 4.9 and 5.1 were treated in the spring of 1971 with fertilizer, lime, and legume seed in various combinations to determine the most effective means of improving pasture production. Yield data have been taken for 2 years and the forage is being analyzed for protein, energy and mineral content.

The results indicate that the type of soil has considerable influence on the practice necessary to improve forage production. Phosphorus application alone increased yields threefold in the limestone soil, and 41% on

the sandstone soil by the end of the second year. In this same time period, lime alone increased yields to about the same extent on both soils, 42% on the limestone and 36% on the sandstone. Molybdenum was found to increase yields slightly on both soils.

The highest yields on both soils have been obtained with lime, phosphorus, renovation and legume seed. Treated areas have had yields as high as 6.2 times the control on the limestone soil. On the sandstone soil the highest yielding treatment has been 2.2 times the control. The response to treatments that did not contain lime was much greater on the limestone soils. A combination of phosphorus, renovation and legume seed increased yields on the limestone soil as much as 5.3 times that of the control, although the pH remained at 5.1. On the sandstone soil the highest yield without lime was only 1.73 times that of the control.

Title: Reseeding Alfalfa in Winter-Injured Stands

Leaders: C. S. Brown and R. F. Stafford, Maine

New studies of overseeded alfalfa were initiated in spring 1972, following severe winterkilling during the open winter of 1971-72. One- and 2-year-old stands of alfalfa, relatively grass free, were included in these studies.

Comparisons were made of the following methods of introducing Iroquois alfalfa into the winterkilled stands: (1) a "frost" seeding broadcast on honeycombed soil in mid-April, (2) a packer (Brillion) seeding on undisturbed soil in mid-May, (3) a packer seeding on soil scarified by light disking in mid-May.

The frost seeding treatment proved much less effective than the packer overseeding treatments, although approximately 30% stand reestablishment was obtained during the 1972 season. The packer overseedings produced stands ranging from 60 to 80% ground cover by early fall. Yields of alfalfa exceeding one ton of dry matter per acre were obtained from these overseedings in 1972. Observations in early spring 1973 indicate that good to excellent reestablishment has occurred.

SECTION VII

ENGINEERING RESEARCH

Title: Regional Project NE-70--Engineering Systems for Forage Crop Production and Use

Leaders: W. L. Kjelgaard (Pa), Chairman, Research Committee; G. F. Rehkugler (NY); R. J. Rowe (Me); D. R. Mears (NJ) and L. F. Whitney (Mass).

Contributors: The Maine, Massachusetts, New Jersey and Pennsylvania Agricultural Experiment Stations

Progress on the regional systems model for forage production and utilization was reported (NJ). A mathematical model which essentially follows the regional flow pattern was successfully formulated and run. Model details are reported in a M.S. thesis by Thomas W. T. Tseng, Department of Agricultural Engineering, Rutgers University (1972). A listing of activity attributes that goes with regional flow charts has been prepared. Work has progressed in modeling weather predictability, activity scheduling and land use. Weather in particular was reported as complex input for the regional model.

Maine reported success in modeling an alternative flow path on the regional chart involving mechanical drying of immature grasses as protein supplement. The model simulates the harvesting system and gives results in term of yield, total digestible energy, quality, land use, scheduling, etc., but primarily involves yield and quality. Other modeling work relates previous work on corn modeling to forage crops in the Northeast.

Mathematical models of plant growth and drying of plant materials have been completed and reported (Mass). Either of these models contain elements and procedures that can be adapted to the regional NE-70 model concept. Work continues in Massachusetts on protein extraction from forages and the systems model for this process.

Completion of the model forage handling and transport system involving corn silage, baled hay and high density bales and wafers was reported (Pa). The program determined transport equipment needs for various forage handling techniques, capacity ranges, haul distances, etc. Calculations of mechanical energy input were made for each solution and show energy requirement variation with each forage handling and transport system.

Title: Engineering System for Forage Crop Production and Use
 (Massachusetts)

Leaders: L. F. Whitney and C. S. Chen, Massachusetts

Results of plant growth studies have produced a generalized model which is useful in the more accurate prediction of growth and development of plants for given environmental histories. More efficient production of crops might be possible as a result of these studies.

Better understanding of the role of diminished change, i.e., shrinkage in the drying of biological materials, makes the prediction and process control more accurate with greater potential for improved efficiency in processing with an accompanying conversion of energy. This is an important extension and improvement of drying theories developed by Lukon and others.

Improved analysis of human food and animal feed production systems from forage is possible with the advent of these studies which explore aspects heretofore based largely on experimental data.

Title: Engineering Systems for Forage Crop Production and Use
 (New Jersey)

Authors: D. R. Mears, G. H. Nieswand, M. E. Singley, T. Tseng,
 Miss Kerry Lu, New Jersey

Several minor modifications were made on the circular barn and its associated systems to improve its performance. The rate at which the silo can be filled was increased by modifying the blower pipe and increasing the speed of the blower.

Adjustments made to the self-feeding silo appear to have solved the problems associated with controlling feed flow to the animals. Both corn and grass silage have been fed through with very little waste and the only control operation needed was releasing the triggers on the wheels.

Last year the time between the last fall filling and the first spring filling was too lengthy and the silo was completely empty by spring. In order to match this time of storage requirement to the feed consumption of the animals, more silo capacity is needed.

The liquid manure system has worked well during the past year. Manure is readily worked through the slots by the cows feet with no human labor required. Flushing by recirculation is done twice a week and since

establishing this schedule in June 1971, there has been no need to raise the gate or to add extra water to the system.

The new ventilation system installed last year continues to work well and the new fan arrangement has virtually eliminated the maintenance problems of the fans and louvers previously encountered. Further work of the air conditioning system is required.

The development of a generalized mathematical model of the entire forage production system is continuing. The forage flow chart representation of the system has been improved. A listing of the key parameters associated with the various steps in the system has been prepared. This model enables one to select the acreage to be devoted to each of several crops, the planting and harvest time, and the labor and machinery resource allocations to maximize the value of the forage produced as determined by total digestible nutrients and protein. Both annual and perennial crops are considered and existing stands of perennial crops and their age are considered, even though the planning horizon of the model is only one year. An important feature of this program is the technique developed to schedule operations which require one, two, three or more consecutive days of good weather for their completion.

Resources which can be limiting include land, labor, machinery, time (which is weather dependent) and ratios of total digestible nutrients to protein of the forage crops produced.

This model has been tested for a limited number of factors and several pathways on the flow chart. It was found that the model responds as it should to changes in the inputs. A severe restriction on the applicability of this model at the present time is the lack of adequate input data. If these data were available, the model would serve to cover a fairly large portion of the decision space associated with planning forage production systems. Further work is needed in making the model more comprehensive and in accounting for the effects of weather on crop growth.

Title: Engineering Systems for Crop Production and Use (Pennsylvania)

Leader: W. L. Kjelgaard, Pennsylvania

Diversity of machine alternatives and interdependence of machine functions within the forage system make it difficult to select and schedule the systems mechanical elements. To evaluate the performance of interacting forage machines requires identification of related factors. A system of mathematical equations will perform the interrelating function and becomes the system model.

The objectives of the model were to determine daily tonnage capacity for various types and combinations of forage transport and handling equipment and values of both mechanical and labor energy needed. Input elements of the models were either fixed or constrained and established definite boundaries of model function.

Models have been developed containing practical machine factors required to transport and handle forage in the form of corn silage, baled hay, high density baled hay and hay wafers. Each forage form has its own pattern of mechanical interrelationships and therefore its separate model. The model begins with field loading of transport machines (which for packaged hay contains several machine alternatives) and ends after handling into storage.

For a given forage handling method, type and number of transport units, field loading rate, haul distance and working time, the calculated tons of forage handled per day were determined. Daily tonnage values can also be divided by working hours per day for estimates of hourly capacity of various systems. Another output is mechanical and labor energy requirements for forage transport and handling. Labor energy proved to have a very low value per ton (about 50 thousandths of mechanical energy required for baled hay transported one mile). Mechanical energy requirements are directly related to operating costs of the system. Energy values also show "conservation of energy" which may become an element of machine selection criteria. Results show that mechanical energy requirements increased linearly with haul distances and that type of forage transport device influenced energy needs.

For corn silage (into tower silos) the average transport and handling energy for 1 mile distance was 1.9 hp-hrs per ton. For baled hay (from field to storage) the average energy for a similar distance was 6.5 hp-hrs per ton. Shifting to a dry matter basis (assuming hay at 15% moisture and corn silage at 65%) corn silage required 5.4 hp-hrs and baled hay 7.6 hp-hrs per ton of dry matter. Trucks showed consistent minimum energy needs in comparison to other transport machines primarily due to less basic weight in comparison to the combination of tractor and wagon and decreased travel time due to higher speed.

Title: Quantitative Determination of Heat and Mass Transfer Coefficients of Forage

Leader: R. J. Rowe, Maine

Work on the application of drying theory to the analysis, design and optimization of continuous flow forage drying equipment has continued. Analysis and simulation of production systems for the harvesting, drying

and handling of grasses and legumes at an immature (vegetative) stage are underway. Particular emphasis is on high protein-low fiber forage which may replace, in part, the feed grains as a source of energy and protein for ruminant livestock.

Title: Development of Belt Lime and Fertilizer Spreader

Leader: R. G. Diener, West Virginia

Project terminated July 1, 1972, and description and specifications of spreader have been published. Tests have indicated effectiveness of 100' throw spreader for hill land fertilization. Excellent distribution patterns are obtained with mixed analysis fertilizers such as 0-46-0 and 5-10-10. In tests with different lime sources, two damp limes gave the greatest throwing distance. Different distances attained with two pelleted lime products were attributed to differences in physical properties of the limes.

SECTION VIII

NUTRITIVE EVALUATION AND UTILIZATION

Title: Regional Project NE-24, The Nutritive Evaluation of Forages

Leader: D. R. Waldo, Ruminant Nutrition Laboratory, USDA-ARS,
Beltsville, Md., Chairman, Regional Research Committee

Experiment stations and other agencies with contributing projects:

The Connecticut (Storrs), Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Vermont, and West Virginia Agricultural Experiment Stations; the U.S. Regional Pasture Research Laboratory, ARS-USDA, University Park, Pa.; and the Ruminant Nutrition Laboratory, ARS-USDA, Beltsville, Md.

Other cooperating agencies: Cooperative State Research Service, ARS-USDA

The objective of the NE-24 regional project is to determine the basic factors controlling the intake of rations based on forages. The contributing projects considered the physical and chemical properties of the ration, the physiological status of the animals and some agronomic factors that may affect chemical composition of forages.

Physical properties of forage based rations for ruminants can influence the intake of digestible energy under certain conditions. Ration intake can be restricted by flow through or the volume of the gastrointestinal tract. A model of fiber disappearance from the rumen was developed that splits any chemically defined fiber into two components--potentially digestible and indigestible (Ruminant Nutr. Lab.).

Reducing particle size of a forage based ration usually depresses digestibility but increases dry matter intake and digestible energy intake. Adequate description of particle size is required to describe or predict effects of particle size reduction. Chopped or ground forage rations, rumen contents and feces were prepared as cell walls, separated by dry sieve analysis, and fitted to the logarithmic normal distribution (Ruminant Nutr. Lab.).

Rumination serves a major role in reducing particle size in the rumen to allow passage. Preventing rumination by molded face masks reduced the intake of forage when allowed equal eating time (Vt.). Ingested cell walls provided the best denominator in an expression of rumination time (Vt.).

The restrictive volume of the GI tract is translated to digestible energy by caloric density expressed as digestible energy per unit volume. Various measurements of density are being considered and studied in trials with wethers (Pa.) or milking cows (Md.).

Chemical properties of forage based rations considered were insoluble and soluble carbohydrate, nitrogen form and minerals. With advancing growth Guinea, Congo, Elephant and Star Bermuda tropical grasses increased cellulose and lignin concentrations but Pangola changed hemicellulose, cellulose and lignin concentrations little (N.Y.). In vitro dry matter disappearance (IVDMD) declined with advancing growth for all tropical grasses. Tropical Guinea grass contained more cell walls, cellulose and lignin but had lower intake and was less digestible than temperate orchardgrass (N.Y.). The most important variables in prediction of IVDMD of tropical forages were acid detergent fiber (ADF), lignin and nitrogen (W.Va.).

Using forages with intake data, lignin was dissolved from acid detergent fiber and its absorbance was measured at 250, 300 and 350 m μ in both acid and base media (Conn.). Difference absorbance was calculated. Difference absorption values of 300 and 350 m μ , obtained from lignin extracted from reed canarygrass, were positively correlated to acid detergent lignin (ADL), ADF, and cell wall constituents (CWC). Legume lignin absorbance values appeared to be quite different from those obtained from grasses.

Nitrogen composition continues to be investigated. Five forages (alfalfa, red clover, timothy, reed canarygrass and orchardgrass) are being used to study relationships between nitrogen composition and rate of cellulose digestion by rumen microorganisms (Me.). Alfalfa had considerably more soluble protein than any of the other forages tested. Alfalfa also contained higher proportions of all soluble amino acids, except alanine and glutamic acid, than the other forages. High levels of soluble proline and methionine were present in the alfalfa.

Several studies considered minerals. Mean percent S in DM of New Hampshire forages were: hay, 0.155; haylage 0.221 and corn silage 0.140 (Md.). Respective S digestibilities were 71.1, 75.1 and 65.2. Phosphorus and sodium appeared to be most limiting minerals in tropical forages (W.Va.). Increased feeding of potassium carbonate from 0 to 120, 240 and 360 g/day to mature Holstein cows on corn silage increased concentration of K, Ca, Mg, total volatile bases and total volatile fatty acids, proportions of isobutyric, isovaleric, n-valeric and n-caproic acids; decreased concentration of Na, proportions of propionic and n-butyric acids and caused no change in pH or proportion of acetic acid (Mass.).

The physiological state of animals affects the voluntary intake of forage rations. Ewes increased orchardgrass hay intake by an average of 22% during the first two postpartum weeks (W.Va.). Animal variation for this increase ranged from 1 to 53%. Generally, intake was related to level of milk production. All of the identical rations fed to both

wethers (Pa.) and milking cows (Md.) were consumed in greater amounts per unit of metabolic body size by the milking cows. Holstein and Zebu cattle digested Guinea grass equally when fed at the same level per unit of metabolic body size (N.Y.).

Plasma amino acids were considered as physiological metabolites that might affect intake (W.Va.). Dry and lactating ewes were fed cut orchardgrass from four growth stages and four levels of N fertilization. Nitrogen fertilization did not affect dry matter intake but lactation increased intake and advancing maturity decreased it. No consistent relationships were observed between plasma amino acids and level of intake.

Plant compositional changes as affected by fertilization, foliar diseases, and germplasm are being considered. Potassium fertilization has produced Climax timothy hays with 1.2 and 3.3% K (Me.). The nutritive value of these hays and the high K hay with 2.5 g MgO/day are being evaluated using sheep. Healthy alfalfa and alfalfa infected with Ascochyta leafspot, Leptosphaerulina leafspot, Stemphylium leafspot, Rust, and Pseudopeziza leafspot have been sampled for IVDMD, CP, CWC, ADF, lignin, and meadow vole feeding trials (Pasture Lab.).

Title: Studies on Allelochemical Properties of Crownvetch and Their Effect on Forage Quality

Leaders: D. L. Gustine and R. F. Barnes, Pasture Research Laboratory, University Park, Pa.; and J. S. Shenk, Pennsylvania

Although crownvetch (Coronilla varia L.) is an acceptable forage for ruminants, it is not readily accepted by meadow voles (Microtus pennsylvanicus), and can be lethal to the voles (see Annual Report, 1971, p. 60).

Compounds have been isolated from fresh cut oven-dried crownvetch that cause death to weanling meadow voles. This activity was detected by weanling vole bioassays, in which weight loss or gain, diet intake, and death were recorded during 6-day feeding trials. The compounds were isolated by extraction of dried, ground forage with 95% ethanol. Non-polar compounds were precipitated by addition of water, while the active compounds remained in aqueous solution. The active compounds remained in the aqueous phase after partitioning with chloroform-ethanol (8.5:1.5) but were extracted into the organic phase during partitioning with ethyl formate. They were further purified by passage through a polyamide column, and then fractionated by preparative thin-layer chromatography. This final step resulted in the isolation of at least one active fraction containing 3 or 4 compounds as determined by analytical thin-layer chromatography. The chemical properties of the compounds isolated suggested that the death of weanling meadow voles fed crownvetch diet is caused by the presence of flavonoid compounds.

Title: Effect of Feeding Crownvetch to Swine

Leaders: P. J. Wangsness and J. L. Gobble, Pennsylvania

Two trials were conducted to determine the performance of swine fed a sample of artificially dried crownvetch (cv) hay which had previously been shown to adversely affect chicks and meadow voles. In experiment 1, two pens of growing Yorkshire pigs (6 animals/pen, 62 lb average weight) were fed a corn-soy ration containing 20% cv or 20% alfalfa (alf). During the first 7 days the cv group lost an average of 1 lb/pig/day and total feed consumption was 34 lb. This contrasted with an average gain of 1 lb/pig/day and 135 lb total feed consumption for the alf group. By day 8, three of the cv pigs exhibited symptoms of ataxia and incoordination. The cv pigs were then switched to the alf ration. The affected pigs recovered within several days and began eating well and gaining weight. The question remained as to whether the cv pigs exhibited symptoms because of the low nutrient intake or because of some adverse constituent in the cv.

Trial 2, a paired-feeding experiment, was designed to answer the question raised in trial 1. The same 12 pigs were allotted into 6 pairs and each pig was placed in an individual pen. The cv pig from each pair was fed ad lib and the daily intake of the alf pig was restricted to the intake of the cv pig. Individual intake of the cv pigs ranged from 5.4-16.5 gm/kg B.W. By 21 days all cv animals exhibited the same symptoms observed in trial 1. Alf pigs were not affected. It is concluded that the symptoms observed were not a result of insufficient nutrient intake but were due to some adverse constituent of the cv sample.

Plasma samples and tissue specimens (brain, spinal cord, muscle, etc.) are currently being analyzed by chemical and histological techniques.

Title: In Vitro Evaluation of Forages

Leaders: W. A. Kendall and R. F. Barnes, Pasture Research Laboratory, University Park, Pa.

A single and two-stage in vitro technique to estimate nutritive levels of forages were compared using forages that had previously been evaluated with animals. Generally, correlation coefficients between the in vitro values and the animal data were higher for the two-stage technique than for the single-stage, but all values were significant at least at the 95% level of probability.

Title: Digestibility of Simazine Treated Alfalfa

Leaders: L. S. Bull and J. A. Schillinger, Maryland

Fiber analyses and in vitro digestion of samples ($n_g = 38$, $n_h = 57$) of alfalfa treated with simazine (0.45 kg/A) were conducted. The results are shown in the table below:

Relationships between various parameters in simazine treated alfalfa.

X (%)	Y (%)	Series	Equation
NFD	DDM	G	$Y = 98.61 - 0.54X$
		H	$Y = 95.23 - 0.44X$
ADF	DDM	G	$Y = 86.47 - 0.18X$
		H	$Y = 105.92 - 0.78X$
Protein	NDF	G	$Y = 44.04 - 0.42X$
		H	$Y = 42.32 - 0.32X$
Protein	ADF	G	$Y = 40.99 - 0.31X$
		H	$Y = 33.49 - 0.03X$
Protein	DDM	G	$Y = 82.68 - 0.10X$
		H	$Y = 85.55 - 0.22X$

Title: Composition and Nutritive Quality of Tropical Forages

Leaders: R. L. Reid and A. J. Post, West Virginia

Analytical work was continued on grass and legume species and varieties grown under uniform fertilization conditions during the rainy season in Uganda. Acid detergent fiber, lignin and nitrogen were significant factors in the prediction of in vitro dry matter digestibility, ADF accounting for the greatest proportion of the variability. Of the mineral components, phosphorus and sodium appeared to be most limiting for animal production. Tannic acid analysis has indicated generally higher concentrations of tannins in legumes than in grasses, with especially high levels in some species, e.g., Desmodium intortum. While concentrations in the majority of grasses were low, some species, e.g., Paspalum commersonii and Digitaria uniglumis, had relatively high values, and such values may be of significance in determining the palatability of the forage. Cell-wall analysis is being completed and a comparison

will be made of the significance of chemical components as they affect the feeding quality of temperate and tropical forages species.

Title: The Nutritive Evaluation of Forages: Energy

Leader: B. R. Baumgardt, Pennsylvania

Studies were conducted to determine nutritive parameters which predict energy intake and allow formulation of optimum diets for animals with varying energy needs. Energy demand levels have been varied by using growing wethers (6 diets, Trial 1; 8 diets, Trial 2) growing Holstein steers (8 diets) and lactating ewes (6 diets). To test our hypothesis that caloric density (DE as kcal/ml) is a better predictor of energy intake than simple energy content (DE as kcal/gram), diets were formulated to vary in density at each of several DE (kcal/gram) levels. Further justification of our hypothesis was obtained since correlations with energy intake were improved when kcal/ml replaced kcal/g in the production equation (r values improved: 0.51 to 0.70, wether trial 1; 0.82 to 0.94, wether trial 2; 0.92 to 0.97, steers). The lactating ewe trial is yet to be analyzed and investigations are continuing to determine the most biologically appropriate method for determining density.

Title: Control of Feed Intake and the Regulation of Energy Balance in Monogastric and Ruminant Animals

Leaders: B. R. Baumgardt, J. L. Gobble, and H. B. Graves, Pennsylvania

Changes in plasma levels of metabolites and hormones were studied in spontaneously feeding, undisturbed sheep. Frequent blood samples were collected from animals maintained in an electronically controlled feeding unit. Activities of a sheep, including drinking, approaching the feeding area, and feeding were monitored by photocells coupled to event recorders. Plasma levels of volatile fatty acids, glucose, and insulin changed before, during, and after meals. The rapidity of these changes support the hypothesis that blood metabolites and/or hormones act as feedback regulators in controlling food intake of individual meals. Plasma growth hormone and prolactin, however, changed little with meal-eating.

Meal-eating behavior was studied in 24 sheep fed two common forages, crownvetch (CV) and alfalfa (ALF). Forage type, time and method of forage harvest influenced eating behavior. Meal number ranged from 12.1/

day with early-cut, ALF haylage to 7.1/day with sheep fed late-cut CV haylage. Rate of dry matter consumption (g/min of eating time) differed markedly between ALF (4.12) and CV (2.94). Relationships between feed characteristics and meal-eating behavior continue to be studied.

Title: The Nutritive Evaluation of Forages: Rumination

Leaders: James G. Welch and Albert M. Smith, Vermont

Feeding sodium-acetate inhibited rumination more than feeding similar molar amounts of acetic acid alone. Sheep were fasted until rumination ceased and then were fed a single meal of hay in conjunction with NaHCO_3 , NaCl , or KHCO_3 in three separate experiments. The rumination of the single meal was delayed by the additive in each case. Rumen samples were obtained by stomach tube and pH and osmolality were measured. There was little association between rumination inhibition and pH changes. When rumen osmolality increased above 350 mOsm., rumination was inhibited. Adding peanut oil to the ration of sheep at a level of 10% produced no change in the rumination activity stimulated by normal feeding of grass hay. Rumination stimulated by polypropylene ribbon in alfalfa meal-concentrate fed fistulated steers had no measured effect on rumen bacteria. Feeding concentrates to straw fed dry cows reduced rumination time as compared to when they ingested only straw as the major part of the ration. Molded face masks fitted to prevent rumination were successful in completely stopping rumination. Steers which were prevented from ruminating ate significantly less forage than steers offered the same roughage for the same period of time but which were allowed to ruminate normally. Comparisons of rumination times per unit of CWC ingested between sheep, goats and cattle of different sizes indicated that metabolic body size adjustments were not adequate in explaining the differences observed. Maturity appeared to be an important factor. Feeding the pH controlled rations supplied by the New Jersey Experiment Station workers produced no uniform data due to consumption problems.

Title: Nutrition, Soil, and Herbage Interrelationships

Leader: D. J. Horvath, West Virginia

Topdressed dolomite and calcite were compared on two soils over a 4-year period to determine their influence on magnesium (Mg) levels of orchardgrass and of the blood of lactating ewes grazing the orchardgrass. There

were significant advantages for dolomite in early spring orchardgrass Mg levels, although not at the hay stage. There were also favorable differences in serum Mg. Specifically, the proportion of ewes with severe hypomagnesemia (< 1.0 mg %) was less on dolomite treated swards.

Title: Factors Affecting the Mineral Composition of Forages in Relation to Animal Nutrition

Leaders: C. F. Gross and G. A. Jung, Pasture Research Laboratory, University Park, Pa.

Forage from grasses and legumes contained from 0.07 to 0.97% Mg and varied with species, cultivar, growth stage, season, and applied Mg and N. Temperature differentially affected Mg concentration in forages of 11 species. Meq. ratios of K to Ca and Mg varied from 0.50 to 2.16. Red and subterranean clovers responded most (54, 36% increase) and reed canarygrass, orchardgrass, and tall fescue least (3, 6, 7%) to applied Mg. Nitrogen fertilization varied with the species. A Lolium x Festuca hybrid contained more than twice the average Mg concentration in timothy or smooth brome grass in spring.

Title: Nutritive Value of Nitrogen and Microelement Fertilized Pasture

Leaders: R. L. Reid, West Virginia and G. A. Jung, Pasture Research Laboratory, University Park, Pa.

Studies were completed on a 5-year (1967-71) trial to the effects of different levels (56, 168, 504 kg/ha) of N, or 504 kg N + Co, Cu, Zn, Mo, S, on the nutrition and reproductive performance of ewes maintained on Potomac orchardgrass in the form of pasture or hay throughout the year, with supplementation of NaCl and P only. Major conclusions reached were: (1) Fertilized orchardgrass, with the exception of 1 year, was adequate to meet the nutrient requirements of breeding ewes and their lambs over an extended period, with no apparent cumulative deleterious effects on the ewes. In 1 year, hay fed to pregnant ewes was harvested late after a wet spring, contained low levels of N, and ewes on the low- and medium-N fertilizer treatments had significant mortality and reproductive losses. (2) High N treatments tended to maintain higher body-weights of the ewes during the winter period, with little difference due to treatment over the grazing season. (3) There was a tendency (not

significant) for lambs born from ewes on high N treatments to be slightly lower in birthweight; there was no other effect of treatment on reproduction or on growth of young lambs on pasture. (4) N fertilization had no effect on DM digestibility of herbage, but in grazing trials in 2 years high N treatments significantly reduced the calculated DM intake of orchardgrass at the early stages of growth. (5) Fertilization treatments had significant effects on mineral composition of the herbage and, for some elements, on composition of blood and tissue of sheep. There was evidence for marginal Cu deficiency in lambs on microelement fertilized pastures, and iodine deficiency (goiter) early in the study was associated with high N and high N + microelement fertilizer treatments. (6) High N fertilization significantly reduced the availability of Mg to lactating goats in balance trials, but had little apparent effect on serum Mg in ewes at any period of the year.

Title: Nutritive Evaluation of Forages: Calcium Metabolism

Leaders: J. L. Evans, J. N. Verdaris and Z. Lelkes, New Jersey

The effect of dietary Ca and pH on serum alkaline phosphatase activity (SAP) was studied in 16 dry Holstein cows during their last 3 months of pregnancy. The diet (DM basis) was about two parts grain to one part corn silage. Corn silage was the same for all treatments and contained 0.29% Ca, 0.22% P, 0.33% Mg and a 4.5 pH. Four grain mixtures (A, B, C, D) were fed to four groups of four cows each. The 2 x 2 arrangement of treatments was made up of lower (-, 0.20%, A and B) and higher (+, 2.19%, C and D) Ca with more (-, 4.5 pH, B and D) and less (+, 6.1 pH, A and C) acid in the grain mixtures. The SAP (fresh serum) and minerals (frozen serum) were determined on prepartum days 84, 56, 28, 14, 7 and 4. Average SAP values were 6.6 (-+), 7.2 (--), 7.6 (++) and 9.7 (+-) mmole p-nitrophenol/liter serum/30 min at 37 C. Significant differences in SAP were related to dietary Ca and pH and to their interrelationship. During the last 28 days before parturition, no increase in SAP occurred in the diet C (++) group but SAP increased in diet A (-+), B (--) and D (+-) groups. For groups A, B, C and D, serum values were: Ca 9.0, 9.3, 9.5 and 9.7; Mg 2.86, 2.82, 2.66 and 2.91; and inorganic P 6.17, 6.48, 6.49 and 6.75 mg/100 ml. Some variations in voluntary dry matter intake were recorded; and, as a result there were some differences in ingested Ca within Ca level. Ingested Ca (grams) and absorbed Ca in grams and percent for diets A, B, C and D were 22, 29, 128 and 183; 7, 9, 35 and 44; 33, 32, 27 and 24, respectively.

In a second trial the effect of dietary H^+ , Na^+ and Ca^{++} on the titratable acidity in rumen fluid and on the pH in rumen fluid and urine was studied in a fistulated steer. The same four grain mixtures were fed once per day with either corn silage (49% of DM) or a grass-

legume hay (29% DM). The titratable acidity (milliequivalents of 1N acid to reduce rumen fluid pH to 4.0/liter of rumen fluid) was greater with hay vs. corn silage diets (117 and 106), at 2 vs. 22 hr post-prandially (122 and 101), with higher vs. lower Ca (113 and 109), and with higher vs. lower Na or pH (116 and 108). The pH of rumen fluid averaged 6.7 at 22 and 6.5 and 6.7 at 2 hr for corn silage and hay diets. The pH of urine was less acid for hay vs. corn silage diets (7.7 and 7.4) and for higher vs. lower Na or pH diets (7.9 and 7.2). It is concluded that the titratable acidity or the total acid-load in the rumen can be influenced by the diet.

Title: Nitrogen Metabolism and Requirements in Beef Cattle

Leaders: R. R. Oltjen and D. A. Dinius, USDA-ARS, Beltsville, Md.

Steers were fed 85% forage diets containing urea, biuret or 2 crude uric acid products during a 90-day growth study. There were four steers per diet and each NPN source supplied 40% of the total nitrogen in the diet. The animals fed either of the two crude uric acid products gained 50% faster than those fed the urea diet and 100% faster than those fed the biuret diet. Feed efficiency was also in favor of the uric acid fed animals. Nitrogen retention trials using the 4 NPN sources were conducted and no significant differences were found in dietary crude protein digestibility nor in percent nitrogen retained.

Formaldehyde readily protected casein and alfalfa meal protein from ruminal degradation as measured by a 21-hr in vitro incubation with ruminal fluid. Formaldehyde treatment at 1% of casein weight resulted in protection of about 90% of the protein when the material was not washed subsequent to treatment. Nearly three times more formaldehyde was required when the material was washed. Protein in alfalfa meal was 70 to 90% protected by formaldehyde at 1% of meal weight; half that amount of formaldehyde gave only 10 to 30% in vitro protection. Protein in alfalfa meal dehydrated at 135 C was more protected than freeze dried meal at each formaldehyde treatment level, an effect that appeared to be additive since untreated dehydrated meal was already 25% protected compared to untreated freeze dried material.

Title: Utilization of Plant and Animal Waste Products and of Forage by Beef Cattle

Leader: D. A. Dinius, USDA-ARS, Beltsville, Md.

Pelleted alfalfa meal was not a satisfactory feedstuff for finishing heifers. In a 5-month feeding trial with 64 beef heifers, those fed the meal gained only 70% as rapidly as those fed grain. Additions of either 5% molasses or soybean oil to the diets had no statistically significant effect on weight gain but the addition of diethylstilbestrol and chlortetracycline tended to increase gains of both grain-fed and alfalfa meal-fed cattle. Carcass grade of meal-fed heifers was lower than that of grain-fed heifers. Preliminary laboratory analysis indicated that some of the protein in the alfalfa meal may have been heat damaged by dehydration and/or pelleting and therefore unavailable to the heifers.

Sawdust was used as a nondigestible diluent in a concentrate diet to inhibit cattle from overeating when initially offered concentrates ad libitum. The cattle had been fed a forage diet and then were placed in feedlots and immediately offered concentrates diluted with 20, 35 or 50% sawdust in the total diet for 10 days; the sawdust was then withdrawn and the cattle continued on the all-concentrate diet. Cattle fed the 20% sawdust diet tended to initially overconsume but then went smoothly onto the all-concentrate diet. The 50% sawdust diet initially limited the intake of cattle but these tended to overeat and then go off feed when the sawdust was withdrawn. In a succeeding study, cattle fed 50, 35 and then 20% sawdust diets for 3 days each had no problems with overeating.

Waste woodpulp fines were fed to 4 steers to determine the dry matter digestibility of the product and to determine whether it would adversely affect ruminal microorganisms. The fines were approximately 53% digestible on a dry matter basis and the rumen microbial population was not significantly altered compared to that of cattle fed conventional forage.

Title: Productivity of Pastures Utilized by Crossbred Angus-Holstein Cows and Calves, 1968-1972

Leaders: J. B. Washko and L. L. Wilson, Pennsylvania

Differences of 0.15 to 0.41 tons of dry matter per acre were noted between three pasture types: (1) Kentucky bluegrass alone, (2) orchardgrass alone, and (3) birdsfoot trefoil, grown with either orchardgrass, reed canarygrass, or smooth brome grass. Kentucky bluegrass was slightly less

productive than the other two types measured in terms of cow grazing days per season. In terms of carrying capacity, the bluegrass sward was inferior to both orchardgrass alone and birdsfoot-tall grass mixtures, furnishing 35 to 40 days less grazing days, respectively. Calculated crude protein and TDN contents of first grazing forages tended to be lower than for second, third and fourth grazings. Crude protein content of pasturage containing birdsfoot trefoil was higher than grass forage alone. The reverse was true for TDN content, since both Kentucky bluegrass and orchardgrass grown alone were higher than birdsfoot trefoil-tall grass mixtures.

Title: Beef Calf Production in New Jersey

Leaders: M. A. Sprague, W. L. Park, D. A. Kniffin, J. C. F. Tedrow,
M. E. Singley, J. R. Justin, R. L. Flannery, New Jersey

A feasibility study was conducted of a hypothetical beef-calf production operation applicable to a 200 acre farm on good soil (Greenwich silt loam) in southern New Jersey. The study indicated a 6% return to management plus interest at 7.5% on capital investment of \$118,900. The operation was based on feeding perennial grass-legume pastures in summer, small grain pastures in fall and spring and corn silage 4 months of the year. No hay was used. Conservative estimates were used of costs, production levels and prices received. Stocking included about 215 head of cows and calves plus 4 bulls. Gross income from calves sold in spring at 35¢/lb was about \$51,000. Calves sold in the fall permitted carrying more cows, but lower prices anticipated reduced the net profit considerably. Calculations were made without irrigation and independent of land cost.

Calf production appears to offer considerable opportunity in suburban areas for productive use of land either laying idle or in marginal farms. Much of this land (in both large and small units) is currently under-used while being held for speculation. Available custom operations and part-time farm management suggest profitable opportunities on small acreages at the present and projected demand price for beef calves.

Title: Effective Use of Bluegrass-Clover Hill Pastures

Leaders: G. C. Anderson and LeRoy Stevens, West Virginia

It is increasingly apparent that pasture treatments on this previously reported study represent "severe" (cattle alone) and "very severe" (cattle and sheep) stocking rates. Effects reflected in spring plant

response and botanical composition are becoming increasingly evident and are considered to be cumulative. Incidence of Digitaria sanguinalis has increased on southern pastures, particularly in the cattle treatments, and Solanum carolinense has increased on northern pastures, particularly with the cattle and sheep treatment.

Two experimental materials with disciplined nitrogen release were examined. Distribution of plant response was improved and response was proportional to level of application and nitrogen released. Exposure mitigated response. Carryover of the slow release material into the 72-73 year is anticipated. It appears that such materials may have real practical merit in removing a major constraint on hill pasture productivity.

Title: Evaluation of Pastures for Dairy Heifers

Leaders: E. M. Kesler and J. B. Washko, Pennsylvania

Two plots each had been seeded to Pennlate orchardgrass or to Iroquois alfalfa-Pennlate orchardgrass in 1971. During the 1972 season yearling heifers were used to graze the plots in rotation. Stocking rate was heavy enough to remove most of the forage in 7-10 days. The Pennlate orchardgrass received four 50 lb/A applications of nitrogen between grazing periods. Plots were sampled for dry matter yield at the beginning of each new grazing period. Season yield of dry matter was 3.31 tons per acre by the alfalfa-orchardgrass plots and 3.77 tons by the nitrogen-fertilized orchardgrass plots. The latter provided more grazing days per acre, 203 as compared with 155 days on the alfalfa-orchardgrass plots. The experiment will be continued.

During a second season of observation, three permanent pasture swards were grazed continuously by yearling Holstein heifers. One area was used as the control. The animals on the second treatment were fed 1 kg supplemental concentrate per head daily. The heifers were restricted to 45% of the area of the third field until a first crop of hay was removed in mid June. Thereafter, grazing was over the entire area. Heifer growth was lowest in both years on the treatment with supplemental feed. That on restricted grazing was slightly better than control during the first season and less during the second year. Adverse weather resulted in spoilage of the hay during the second year. A third year of observation is planned.

Title: Management, Preservation and Utilization of Grassland Crops for Dairy Cattle

Leader: J. C. Derbyshire, USDA-ARS, Beltsville, Md.

Twenty milking cows were fed a high energy (3.2 Mcal DE/kg) ground and pelleted ration and long hay at an 84:16 ratio. This maintained milk production but depressed butterfat test from 3.47 to 2.13%. Cows blocked on the basis of initial production were then randomly assigned to four pelleted rations in 4 x 4 Latin square trials of 28-day periods. The rations, fed ad lib, were 15 and 30% wheat straw and 15 and 30% beet pulp, passed through a 4.8 mm screen and incorporated into the basal pellet. The respective ration effects were: kg milk ($P < .005$) 26.4, 25.5, 27.0 and 26.6; percent butterfat ($P < .001$) 2.93, 3.32, 2.63 and 2.87; kg FCM ($P < .005$) 22.1, 23.1, 21.5 and 22.1; percent SNF ($P < .005$) 8.86, 8.80, 8.93 and 8.92 and percent C.P. ($P < .005$) 3.22, 3.13, 3.28 and 3.26. Intakes (kg) of indigestible acid-detergent fiber were 2.63, 3.62, 1.64 and 1.80, respectively. Butterfat test was most closely related to this feed component. The respective C₂:C₃ ratios, 1.7, 3.4, 1.7 and 2.4, were directly related to percent BF within feed ingredients. Extremely adverse weather conditions precluded a valid study and interpretation of stage of maturity effects on the feeding value of companion hay and silage.

Title: Investigations on the Utilization of Forage by Sheep

Leader: P. J. Reynolds, USDA-ARS, Beltsville, Md.

Alfalfa meal treated in the dehydrator with 0, 1 or 2% of formaldehyde was used as 75% of the diet of ram lambs in a digestion experiment. Dry matter digestive coefficients at 0, 1 and 2% formaldehyde were 67.4, 60.5 and 56.1, and crude protein digestibilities were 63.1, 41.6 and 29.3, respectively. The same treated alfalfa meals were used to supply 25% of the diet (about 35% of the crude protein) for growing-finishing ewe and ram lambs. Average daily gains over a 50 day feeding experiment were 0.142, 0.186 and 0.158 kg at 0, 1 and 2% formaldehyde, respectively. The decreased dry matter and crude protein digestibilities observed with increasing level and crude protein digestibilities observed with increasing level of formaldehyde suggest that the alfalfa protein was over protected. The over protection, however, was not evident in the feeding experiment, where an apparent increase in rate of gain and feed efficiency was observed at 1% formaldehyde.

Title: Preference Studies with Sheep

Leader: G. A. Jung, Pasture Research Laboratory, University Park, Pa.

Exploratory studies were undertaken to determine whether we could assess the preference of sheep (heavy ewes) for certain grass species, cultivars of a species, and for grass receiving several rates of nitrogen fertilizer. Even though timothy represented only 5% of the entries, it was rapidly located and grazed by the ewes. A comparison of orchardgrass cultivars illustrates the wide range (17 to 47% removed after 24-30 hr) in preference for this species. Preference observations will be correlated with plant constituents when chemical analyses are complete. The technique provides a rapid and inexpensive assessment of forages for plant breeders without destroying their plants. Snow fence was used to enclose one replication at a time and was easily moved to another replication by 2 or 3 men in a few hours.

Title: Preservation and Nutritive Value of Forages and Grains

Leaders: T. A. Long, J. B. Washko, and L. L. Wilson, Pennsylvania

The nutritive value of corn, sorghum, and bird resistant sorghum was compared using sheep growth and metabolism trials. All grains were stored in small experimental silos; treatments were dried, high moisture, and high moisture plus the addition of an acetic-propionic acid mixture. A mixture of dried grains provided the final treatment. Average daily gains for the 35-day growth study ranged from 0.42 to 0.66 lb/day with feed efficiencies, on a grain alone basis, of 3.52 to 5.90 lb grain/lb gain. Highest ADG and feed efficiency were recorded for animals fed high moisture corn with acid addition. Carcass characteristics of the slaughtered lambs were similar for all treatments. Digestion coefficients from the metabolism trial were for crude protein 56.5% to 69.2%, and for energy from 69.9% to 74.3%. The ration containing dried non-bird resistant sorghum was superior in protein and energy digestibility.

Title: Forage Soluble N Effects on Cellulose Digestion and NH_3 Production by Rumen Microorganisms

Leaders: W. P. Apgar and E. C. Prigge, Maine

Five forages (alfalfa, red clover, timothy, reed canarygrass and orchardgrass) are being used to study relationships between nitrogen composition

and rates of cellulose digestion and NH_3 production by rumen microorganisms. Alfalfa had consistently more soluble protein than any of the other forages tested. Alfalfa also contained higher proportions of all soluble amino acids, except alanine and glutamic acid, than the other forages. High levels of soluble proline and methionine were present in alfalfa. In vitro cellulose digestion was determined at 3, 6, 9, 12, 15 and 21 hr incubation times. At the 21-hour incubation time, cellulose digestion was significantly correlated with total soluble N ($r = 0.69$) and soluble free amino acids ($r = 0.69$). At earlier incubation times cellulose digestion was not significantly related to soluble N fractions. However, NH_3 production at 3 hr was significantly correlated with total soluble N ($r = 0.88$), soluble free amino acids ($r = 0.83$) and soluble nonamino acid N ($r = 0.73$). As incubation time increased the relationship of NH_3 production to these fractions decreased. There appeared to be an inverse relationship between soluble proline content and initial NH_3 production among the five forages, the legumes being higher in soluble proline and having lower initial NH_3 production than the grasses.

SECTION IX

SILAGE RESEARCH

Title: Influence of Date of Planting on Yield Responses of Corn Varieties Differing in Season and Maturity

Leader: W. W. Washko, Connecticut (Storrs)

A 4-year study was conducted to evaluate the responses, in terms of silage and grain yield, of several corn hybrids differing in season of maturity to date of planting. The hybrids, with rated (advertised) maturities, were: G-11A, 94 days; Pa. 602A, 105 days; C723X, 115 days. Plantings were made at weekly intervals in May, the period generally bracketing corn planting in the state.

Generally, the highest yields of silage were obtained from planting at mid-May. In grain yield, however, the earliest maturing variety produced increasing yields the later it was planted; the intermediate variety produced declining yields the later the planting after May 10, and the latest maturing variety produced the highest yield at the first date of planting (May 10), with yields declining thereafter.

Title: Influence of Date of Planting on Yield and Maturity of Corn Grown for Silage

Leader: V. H. Holyoke, Maine

A 3-year study has been completed that considered the influence of four planting dates on the yield and maturity of two corn hybrids. Plantings were made at 10-day intervals beginning on May 10.

The hybrids consisted of one short season variety requiring about 1500 heat units for maturity and one full season hybrid requiring about 1850. The experiment was laid out in a randomized complete block with four replications.

Results are now being summarized but preliminary results indicate that at the earliest planting date the full season hybrid produces higher yields, but at the three later planting dates there is no yield difference.

Title: Influence of Handling, Storage, and Processing Variables on Feed Value of Stored Forages

Leader: H. K. Goering, USDA-ARS, Beltsville, Md.

The effect of adding corn grain to green and reconstituted forage on ensiling properties was studied in a laboratory experiment. These effects were evaluated by measuring fermentation end-products.

Direct chopped and reconstituted alfalfa forages were ensiled with 0, 5, 10, 15, and 20% corn meal added on a wet weight basis in 1/2 pint jars. The fermentation period was 28 days with the fermentation of duplicate jars terminated for each treatment at 1, 2, 4, 8, 16, 32, 64, 128, 256, 504, and 672 hours. The fermentation patterns were determined by measuring the composition of the fresh forage and the fermented end-products of each jar over the experimental period. Lactic acid production for the experimental period averaged 7.5% of dry matter for reconstituted forage and 11.5% for the fresh ensiled forage. The pH value was lower for the fresh ensiled forage at the end of the experimental period. The addition of corn meal to forage tended to decrease the buffering capacity and reduce the total acid produced. With the fresh ensiled forage, the pH was 4.1 for the 20% corn meal addition compared to 4.6 with zero addition of corn meal. The effect of adding corn to forage and ensiling was to reduce the buffer capacity making it possible to lower the pH quickly with the production of less total acid. It appears that the low buffering capacity of corn was a more important contribution to the silage fermentation than its starch fermentation.

The importance of heat damage to proteins in hay, hay-crop silage, and corn silage is being determined. One hundred and ten samples in each of the above classes have been collected and assayed for heat damage. Computation of the data is in progress.

Title: Formic Acid as an Additive to Forage for Ensiling

Leaders: D. R. Waldo and J. C. Derbyshire, USDA-ARS, Beltsville, Md.

Plasma of heifers fed untreated silage containing 2.6% N had lower branched (valine, isoleucine, leucine) amino acids and higher serine and glycine than that of heifers fed formic silage. Casein infusion duodenally at $0.27 \text{ g N/kg}^{3/4}/\text{day}$, or about 1/6 of feed N, removed about 2/3 of these differences. Silages prepared similarly and containing 2.2% N were fed to growing heifers either with no nitrogen, urea or formaldehyde treated casein at 1.16 g N/kg wet silage. On control silage

daily gains were 0.22, 0.19 and 0.38 kg; on treated silage gains were 0.37, 0.39, and 0.59 kg. The response to casein supplementation indicated an inferior quality of nitrogen in both silages. Nitrogen should have been adequate in quantity; gain was not changed by urea supplementation. Intakes were affected little by casein supplementation so efficiency of utilization must have improved.

Title: Energy and Nitrogen Utilization of Corn Silage With and Without Added Urea or Soybean Meal

Leader: J. B. Holter, New Hampshire

Growing dairy heifers and dry cows were fed corn silage with or without urea (0.5%, added at ensiling) or soybean meal (2.8% added at feeding) to measure efficiency of use of energy and nitrogen. Urea supplementation gave highest ad libitum intake.

At maintenance rate of feeding, partition of gross energy (GE) in corn silage was not significantly affected by forage treatments except that methane energy loss was higher (8.5 vs. 7.6% of GE) for both supplemented silages than for the control silage.

Urea and soybean meal supplementation increased crude protein digestibility (64 vs. 48%) over control silage without affecting urinary nitrogen loss. This improved nitrogen digestibility was reflected in higher positive retention of tissue nitrogen.

Urea is recommended as an economically advantageous nitrogen supplement for corn silage fed to heifers and dry cows.

Title: Sulfur and Methionine Supplementation of Corn Silage

Leader: L. S. Bull, Maryland

Steer trials on the effects of various S supplements in a corn silage diet have been completed. Supplementation with Na_2SO_4 or M-analog resulted in a response in digestibility and N-utilization was improved by all supplements (Na_2SO_4 , M-analog, and dl-methionine). When fed to lactating cows (6 per treatment), all of the supplements resulted in slightly greater increases in milk fat percentage and a greater persistency of actual milk production and FCM. Intake was not affected. Some plasma amino acids were affected by supplementation.

Samples of hay, haylage, and corn silage plus feces from steers fed these materials at the University of New Hampshire were analyzed for S to gather data on concentration of S and its relationship to digestion of diet. The means \pm SE for %S (DM) were: hay = 0.155 ± 0.017 , haylage = 0.221 ± 0.016 , corn silage = 0.140 ± 0.014 . Apparent digestibilities for S were (mean \pm SD): 71.1 ± 4.21 , 75.1 ± 1.33 , and 65.19 ± 3.05 for hay, haylage, and corn silage. Digestibility was not related to the S content of the feeds in this study.

Title: Effect of Potassium Carbonate to All Corn Silage on Cow's Rumen Fermentation Pattern

Leaders: H. Fenner and W. G. Colby, Massachusetts

To a ration of corn silage of constant intake were added 0, 120, 240 and 360 g of K_2CO_3 . Daily rations were offered in portions of 1/3 and 2/3 corresponding to time intervals between morning and evening feedings. As parameters of changes in rumen fermentation resulting from the K_2CO_3 supplementation served H_2O consumption, pH, and concentration of organic and dissolved inorganic rumen fluid constituents. Increased potassium carbonate in the ration did not change pH and acetic acid proportions in the rumen, but decreased the proportions of propionic, n-butyric acid and the concentration of dissolved sodium. Increases were observed in concentrations of total volatile bases, total VFAs, proportions of isobutyric, isovaleric, n-valeric and n-caproic acids and the contents of dissolved potassium, calcium and magnesium. Water intake was lowest with rations supplemented at the lowest level of potassium carbonate followed by the straight silage ration and then paralleling the electrolyte levels of the rations. There was a marked increase of the average water consumption from the first to the last feeding period. Results demonstrated that water consumption, electrolyte intake, adjustments of contributing electrolytes from body fluids and organic acid levels in the rumen fluid are used to maintain homostatic conditions for the microflora in the cow's rumen. Digestibility of the ration was assumed not to be affected by the potassium supplementation.

Title: Feeding Pellets Made from the Whole Corn Plant

Leaders: J. H. Vandersall, D. A. Lanari and R. W. Dunning, Maryland

Pelleting the whole corn plant is an alternative to making silage which has the advantage of silage in maximizing yield of energy per acre and, at the same time, allows commercial handling and shipping. Studies are

underway to find how these pellets best fit into a dairy feeding system. Intake and digestibility trials with steers and short-term milking experiments with cows have been conducted. Results show that pelleting increases consumption of the whole corn plant over that of corn preserved as silage. However, digestibility of the pellets is lower than that of silage for both protein and energy, especially the fibrous portion of the energy source.

Title: Sunflowers for Silage

Leader: N. A. Clark, Maryland

Corn silage is the leading producer of energy for dairy cattle on a per acre single crop basis, but it is possible that certain multiple cropping sequences might outproduce corn in Maryland. In such a multiple crop sequence, a logical choice for a winter crop would be a cereal harvested as silage or a short season barley harvested as grain. The summer crop should be fast-maturing, highly productive, and drought tolerant. Drought tolerance is especially important because the winter crop leaves the soil low in moisture for the succeeding crop and, if summer rainfall is sparse, most crops will suffer. Sunflowers look promising for the summer crop because they are drought tolerant and produce substantial tonnage in a short period of time.

The objective of this study is to determine the potential yield and feeding value of sunflower silage. An experiment was conducted using a factorial arrangement which consisted of two fertilizer levels, three plant populations, and four sunflower varieties. The plots were planted on June 16 and harvested on August 23 when the plants were just beyond the flowering stage. At the time of harvest, plant dry matter was approximately 13%.

Neither varieties nor fertilizer levels resulted in statistically significant yield differences. Yields did increase, however, as populations increased, with the differences statistically significant at the 5% level. The results indicate that the optimum population level may not have been attained even though the plants were spaced only 3 inches apart in 30-inch rows. This is a population of nearly 70,000 plants per acre. Chemical determinations of the digestible components in the forages have not yet been completed.

SECTION X

ENVIRONMENTAL RESEARCH

Title: Disposal and Utilization of Dairy and Poultry Manures by Land Application

Leaders: H. D. Bartlett and L. F. Marriott, Pennsylvania

Liquid manure from dairy cows was applied below the surface of an orchardgrass sod at annual rates of 0, 15, 30, 45, 60 and 75 T/A (dry matter) during 1969, 1970 and 1971. The 15-ton rate applied approximately 700 lb N/A/year. No manure was applied in 1972. Suction lysimeters were installed at 1, 2, 3 and 4 ft depths. Soil samples, suction lysimeter water samples and yields were taken in 1972. Water samples from the check plots at all depths averaged below 10 ppm N (as NO_3) during 1972. NO_3 -N in water samples from the 15-ton treatment decreased to below 10 ppm at 1, 2 and 3 ft but was still 12 ppm at 4 ft. NO_3 -N in water samples from higher rates of manure remained generally well above 10 ppm except at 1 and 2 ft on the 30-ton treatment. Yields in 1972 were 1.5, 3.0, 3.2, 3.6, 3.6 and 3.6 T/A for the respective treatments, with maximum percent N in the grass of 3.77, 2.96 and 3.35 for each of the three cuts. Soil N (Kjeldahl) in the top 18 inches plus estimated plant removal accounted for 70 to 100% of the applied N.

Title: Land Disposal of Sewage Sludge (Agronomic Aspect)

Leaders: R. W. Duell, R. B. Alderfer, and R. L. Flannery, New Jersey

The effects of 10, 20, and 40 tons dry matter/acre/year of domestic sewage sludge on soil, water, air, and plants will be monitored. Base-line information on soils characteristics and hydrologic nets are being established on quarter-acre plots of three coastal plains soils. Midland bermudagrass will be established on these previously unfertilized, low-nutrient sandy soils, and rye will be drilled into the bermudagrass each fall. Both crops will be harvested and analyzed for potential pollutants periodically. Soil water and ground water will be analyzed similarly. Changes in soil moisture, nutrients, and organic matter will be determined periodically. The fate of potential pollutants in the periodically applied sludge will be summarized.

Title: Grazing Studies of Grass Irrigated with Industrial Effluent

Leaders: G. A. Pearson and W. G. Knibbe, USDA-ARS, Norfolk, Va.;
and G. A. Jung, Pasture Research Laboratory, University
Park, Pa.

Grazing studies were undertaken in cooperation with the University of Delaware to evaluate the nutritional value of grass irrigated with effluent from a food processing plant at Bridgeville, Del. Estimates of the nutritive value of grass rotationally grazed at 28-day intervals indicate that the nutritive value increased markedly from June to mid-November. During that period cattle gained 1075 kg/ha of which about 494 kg could be attributed to feeding a concentrate. Grass receiving applications of fertilizer or effluent and fertilizer appeared to have a slightly higher nutritive value when grazed than when clipped monthly and was markedly superior to grass that received no supplemental water and fertilizer. Nonstructural carbohydrate concentration in the tops of grasses at the grazing site decreased markedly from spring to summer. This could explain the relatively poor performance of cattle during the summer of 1971 when concentrates were not fed. It also suggests that better animal performance might be expected than that observed to date if studies were conducted in spring. Samples collected where effluent from corn processing was sprayed on grass were superior in providing readily available energy than were untreated samples collected close by.

Title: Manure and N Effects on Corn Yield and Chemical Composition of Soil Water

Leaders: J. L. McIntosh and K. E. Varney, Vermont

Four rates of manure and five rates of N were applied yearly in a factorial arrangement to a Pantan clay soil (Typic Ochraqualf). Applications of 120 kg/ha of P and 90 kg/ha of K were made each year to all plots. The plots were planted to corn (*Zea mays* L.). The objectives of the study were to study the effects of continuous corn and manure and N treatments on the physical and chemical properties of the soil and on the growth, yield, and mineral composition of the corn plants over a period of at least 5 years.

During years of normal or less than normal rainfall (1965-67), manure application significantly increased yields of corn grain and stover. Averaged over all treatments of N, plots receiving 66 tons/ha of manure yielded 2.04 tons/ha more than no-manure plots. This response is especially significant in that basic applications of P and K had been made and starter P used at planting each year. For these years, the first increment of N (56 kg/ha) increased yields on unmanured plots. Higher

applications of N reduced yields. Where manure was applied, there was no significant response to N.

During relatively wet years (1968-69), manure had no beneficial effect on corn growth and yield. The highest, or 66 ton/ha, manure application appeared to be detrimental, particularly where N had been applied. Nitrogen, on the other hand, significantly increased growth rate and yield of corn grain and stover at all levels of manure. For example, plots receiving 224 kg/ha of N yielded 5.51 tons/ha more than no-N plots.

Manure treatments increased percentage of K by as much as 0.30% in the corn ear leaves but decreased Ca and Mg. Manure had little effect on the percentage of N and P. In 1969, a wet year, manure reduced N from 2.72 to 2.44% when averaged over all treatments of N.

Chemical analysis of small plants showed the same trends as did analysis of ear leaves. Percentages of Al and Fe were high. But Al varied proportionally to applied N and inversely to manure. For all treatments of N, manure decreased Al from 139 to 85 ppm.

Manured plots were slightly but consistently higher in soil moisture. Small differences of about 1% were measured when the soil was near saturation (43% moisture). Differences of 2.5% were measured 1 week later when the soil was near 30% moisture.

Title: Roughage Type and the Nutrition and Health of Ruminants

Leaders: B. R. Baumgardt, T. A. Long and H. Rothenbacher, Pennsylvania

The forage evaluated in this study was harvested from plots used in project 1787 to measure the effect of manure application on $\text{NO}_3\text{-N}$ content of soil water at varying depths. The manure applied had an average dry matter content of 12.5% and contained 2.35% total nitrogen on a dry matter basis. Treatments were applied to test plots of Hagerstown silt-loam soil seeded with orchardgrass. The treatment supplied 0, 15, 30, 45, 60 and 75 tons of moisture-free manure per acre per year. This is equivalent to 0, 700, 1400, 2100, 2800 and 3500 lb of total nitrogen per acre. The tons of forage harvested per acre for the three cuttings in 1971 were 0.83, 2.61, 2.86, 2.47, 2.35 and 2.42. This harvested forage removed 30, 143, 172, 149, 137 and 143 lb of nitrogen from the soil. Plant protein content on a dry matter basis was 11.3, 17.1, 18.8, 18.9, 18.3 and 18.4%, and plant nitrate-nitrogen ($\text{NO}_3\text{-N}$) content was 645, 1544, 2169, 2347, 2272 and 1974 ppm at application levels of 0, 15, 30, 45, 60 and 75 tons of manure dry matter per acre, respectively. Other tissue analysis results have not been summarized. These results indicate that the forage resulting from the 0 to 15 ton application levels would be an acceptable animal feed. However, there appears to be little plant response to application levels higher than 15 tons per acre.

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Recipients of Graduate Degrees -- 1972

<u>Name</u>	<u>Institution</u>	<u>Adviser</u>	<u>Thesis Title</u>
<u>M.S. Degree</u>			
Amos, Roger	West Va. Univ.	D. J. Horvath	Further studies on the effectiveness of dolomitic limestone compared to calcic limestone, when applied as a liming agent in the prevention of hypomagnesemia.
Campbell, T. A.	Univ. Maryland		Inheritance of resistance to <u>Colletotrichum trifolii</u> in alfalfa.
Forer, Lyle B.	Penn. State Univ.	F. L. Lukezic	Survey and studies on Anthracnose of crown-vetch and other legumes caused by <u>Colletotrichum</u> sp.
Leahey, John M.	Univ. of N.H.	J. B. Holter	Wilted haycrop silage versus hay in dairy rations.
Manosalvas, Luis W.	Penn. State Univ.	E. M. Kesler	Management of permanent pastures for heifers.
Post, A. J.	West Va. Univ.	R. L. Reid	Nutritive value of tropical forages.
Tan, Geok-Yong	Univ. of N.H.	G. M. Dunn	Relationship of stomatal length, frequency and pollen-grain diameter to ploidy level in <u>Bromus-inermis</u> Leyss.
Tsang, Wen-Taur	Rutgers Univ.	D. R. Mears	A comprehensive model of systems for forage production.

Recipients of Graduate Degrees -- 1972 (continued)

<u>Name</u>	<u>Institution</u>	<u>Adviser</u>	<u>Thesis Title</u>
<u>Ph.D. Degree</u>			
Barnes, W. J.	Penn. State Univ.	B. R. Baumgardt	Caloric density of the ration and feed intake of cattle and sheep fed rations formulated from natural feedstuffs.
Daniel, Kesete	West Va. Univ.	R. L. Reid	Zinc metabolism and nutrition of grazing sheep.
Haag, W. L.	Penn. State Univ.	R. R. Hill, Jr.	Comparison of methods of selection for disease resistance in alfalfa.
Kahle, E. B.	West Va. Univ.	R. L. Reid	Amino acid nutrition and metabolism in grazing sheep.
Shinde, P. A.	Penn. State Univ.	F. L. Lukezic	Studies on role of bacteria in root-rot and wilt of alfalfa.



